Volume 29 NOVEMBER, 1922 Number 3

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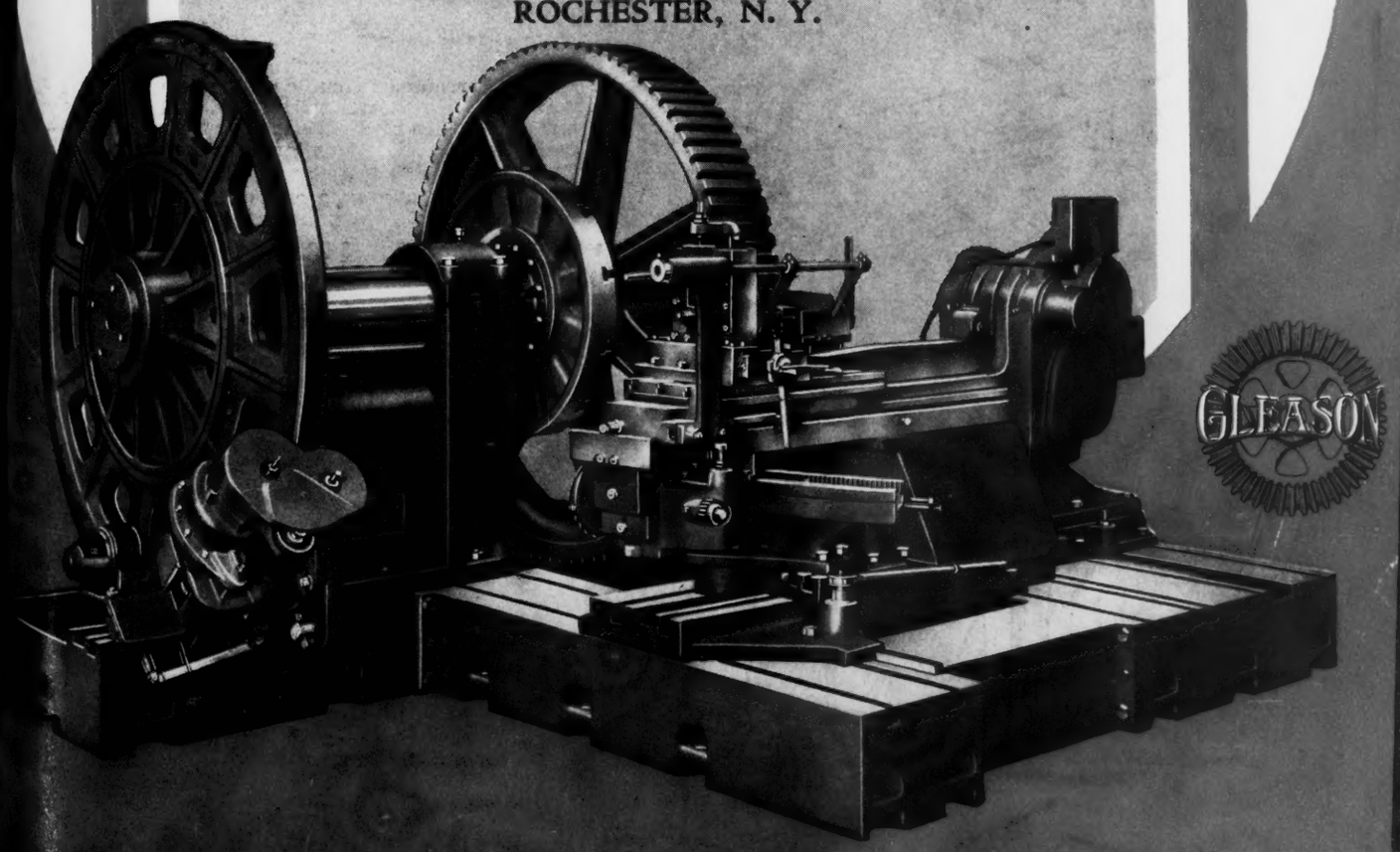

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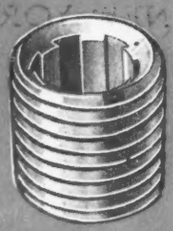

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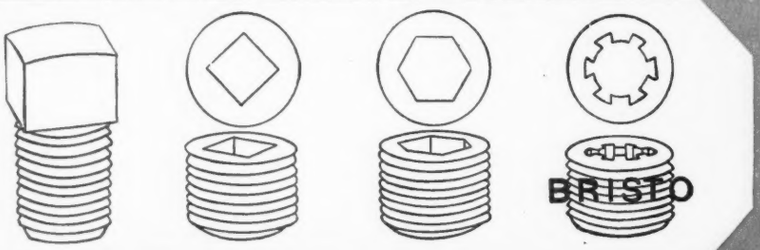

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SIMONDS

VOLUME 29 **MACHINERY** NUMBER 3

NOVEMBER, 1922

THE INDUSTRIAL PRESS, 140-148 LAFAYETTE ST., NEW YORK CITY

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In December MACHINERY the Simmons Method of Making Hobs will be fully described. This number will also feature developments in Die-casting, including the Design of Dies, Die-casting Alloys, Die-casting Machines, and the Design of Parts for Die-Casting

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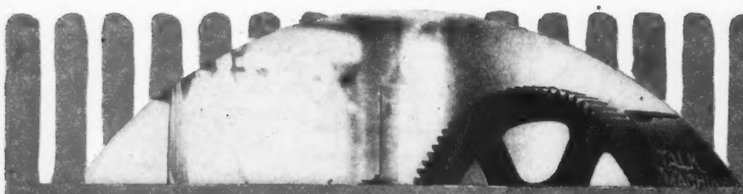

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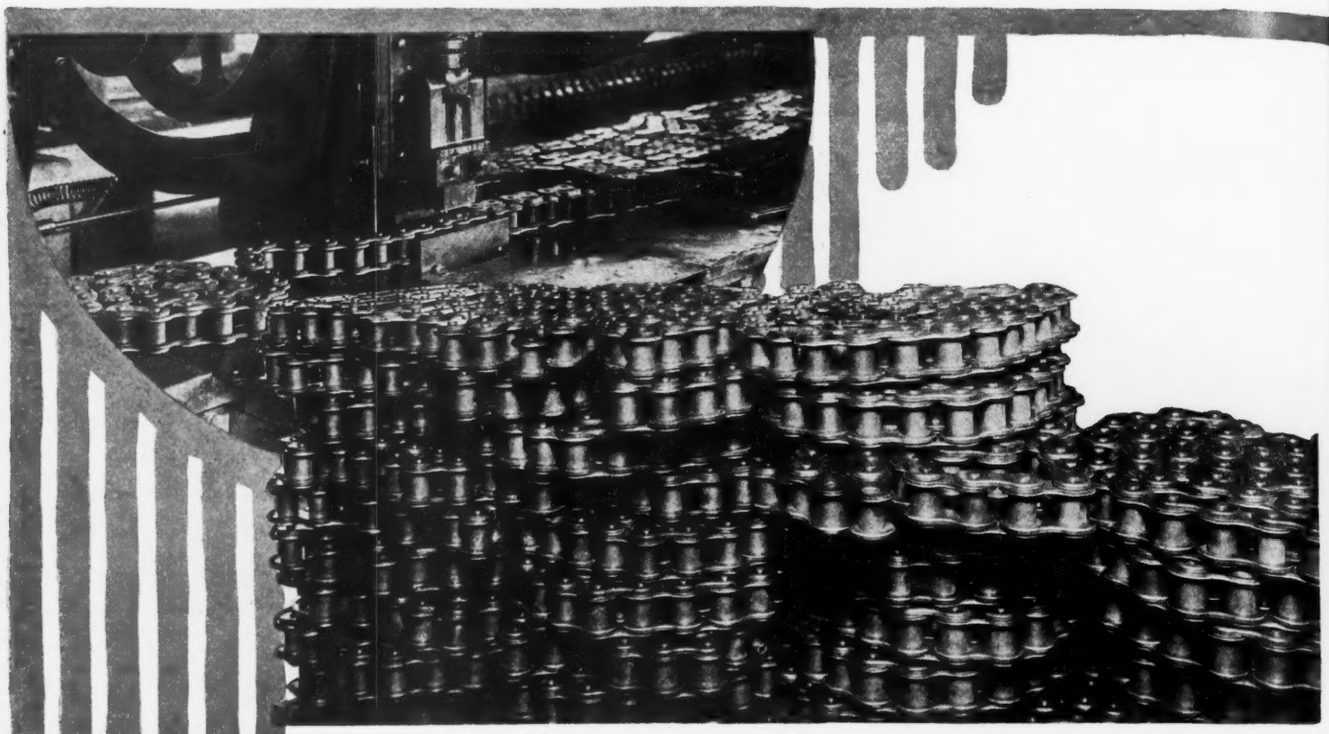


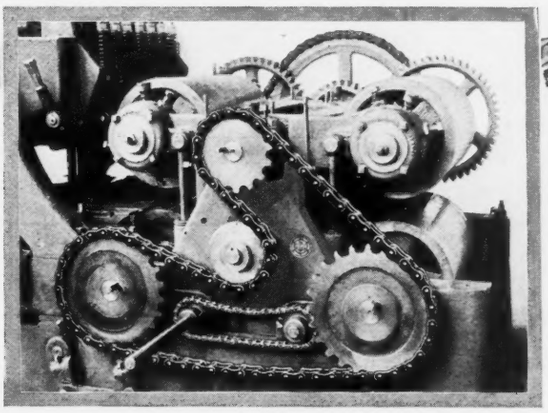
Efficiency Of Chain Drives

THE subject of Transmission and Conveying as it applies to the shop, the factory—to industry in general—was featured last month and is continued in November MACHINERY. The analysis of chain and sprocket action presented by Mr. Bartlett of the Diamond Chain and Manufacturing Company, in his article "The Efficiency of Chain Drives" is of special value to designers and to users of mechanisms in which chain is employed, and interesting and instructive to every reader of a technical paper. Transmission equipment also has a special showing in the advertising pages—manufacturers in this line making their announcements tie up with the feature.

Latest Mechanical Developments

NOVEMBER MACHINERY 1922

Efficiency of Chain Drives



An Original Analysis of Chain and Sprocket Action

Low Numbers of Teeth and Incorrect Center Distances as Causes of Appreciable Variations in Angular Velocity and a Reduction in Efficiency

By G. M. BARTLETT
Chief Engineer,
Diamond Chain & Mfg. Co.,
Indianapolis, Ind.

THE action of a chain as it travels over a sprocket having ten teeth may be compared with the action of a non-slipping belt traveling over a ten-sided prism. The action of the belt would not be as smooth as if the prism had twenty sides, nor would the action over a twenty-sided prism be as smooth as over a forty-sided one. This is the reason that the use of sprockets having less than twelve or fourteen teeth is not usually recommended by chain drive engineers. Nevertheless, it can be shown that a pair of sprockets with a low number of teeth and the proper center distance can be more efficient than a pair with a larger number of teeth and the wrong center distance. It would not be correct, therefore, to say that under no circumstances should a sprocket be used with less than twelve teeth.

Cause of Fluctuations in Angular Velocity

The conditions that cause fluctuations in angular velocity can best be illustrated by diagrams in which the sprockets are shown as polygons. The number of sides in each polygon represents the number of teeth in the sprocket, and the length of each side is equal to the pitch. The action that takes place in all sprockets is most clearly shown by assuming a very low number of teeth, as, for instance, three, four or six.

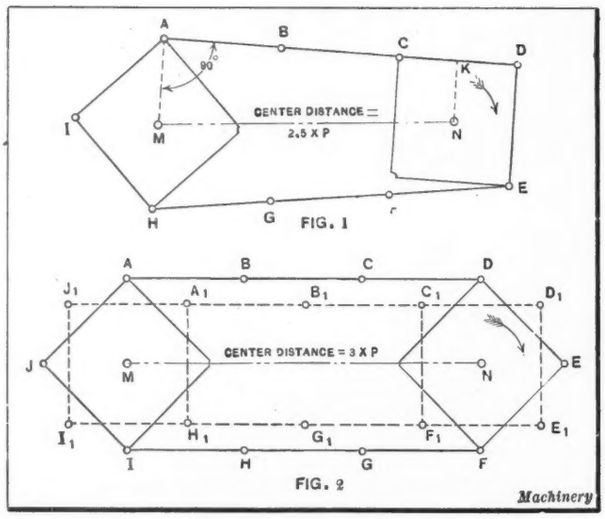
Fig. 1 shows a four-toothed sprocket driving another four-toothed sprocket. Since the number of teeth is the same in the two wheels, the driven sprocket will make exactly one revolution for every complete revolution of the driver; also the driven sprocket will make exactly one-quarter of a revolution for every one-quarter revolution of the driver. But for anything less than a quarter of a revolution this is not true. Let us suppose that the driver is turning with a uniform angular velocity. In the position shown, *NK* is only about seven-tenths as long as *MA*. Hence the angular velocity of the driven wheel at this instant will be only seven-tenths the angular velocity of the driver. After the driver has turned through about one-eighth revolution, the roller *C* will be on top, and the link *IA* will be nearly horizontal. The relation will then be reversed, and the driven wheel will have increased its angular velocity so that it will be about 1.4 times the velocity of the driver. In another one-eighth turn the driven wheel will again be running slow, and so on. The total variation in the speed of the driven wheel is in this case 0.7 to 1.4 or 1 to 2. As the number of teeth is increased this variation becomes less pronounced.

In Fig. 2 is shown the same pair of sprockets with the center distance increased by about one-half the pitch and with one link added to the total length of the chain. In this case *MA* and *ND* always make the same angle with the driving strand *AD* of the chain, and being of the same length, the angular velocity of the driven sprocket is at all times exactly equal to that of the driver; hence, instead of a 100 per cent fluctuation in speed there is no fluctuation. Moreover, the conditions in Fig. 2 allow the use of a chain whose length is a multiple of twice the pitch, while in Fig. 1 an offset link is required, the chain length being an odd multiple of the pitch. Furthermore, the non-driving strand of the chain in Fig. 2 is always of the same length, while in Fig. 1 it is alternately tight and slack during every one-eighth part of a turn of the sprockets. If the number of teeth in the two equal sprockets is odd, the same conditions would hold; hence, the following general rule:

When two sprockets have the same number of teeth, the condition for no fluctuation in the angular velocity of the driven wheel and no whipping of the slack strand of the chain is that the center distance must be an exact multiple of the pitch.

This article on chain drive efficiency illustrates the practical value in engineering work of analyzing carefully every element that may prove of importance. While the power losses in well-constructed chain drives are very slight, it is an interesting fact, as shown by this analysis and by actual tests, that the efficiency may be considerably increased under certain conditions by merely changing the center distance whatever slight amount is required to avoid fluctuations in the angular velocity of the driving and driven sprockets. The effect of such fluctuations on the efficiency of different classes of sprocket combinations is dealt with in this important contribution to the literature on the correct design of chain drives.

When the velocity ratio is not 1 to 1, it is impossible to obtain a theoretically uniform angular velocity ratio, although if the number of teeth is large enough and the chain sufficiently long, the elasticity of the chain may be sufficient to absorb the slight variations in velocity that theoretical conditions would produce.



Figs. 1 and 2. Sprockets shown as Polygons to illustrate Fluctuations in Angular Velocity

Determining Maximum and Minimum Speed Variations

Fig. 3 illustrates a general case where the velocity ratio is not 1 to 1 and where the center distance is such as to produce the maximum variation in the angular velocity of the driven sprocket. If lines SB and OC are drawn through the center of the two sprockets perpendicular to the center line BC of the chain, the distance from B to C is the *span of the chain*. In Figs. 3 and 4 this span is not an exact multiple of the pitch, but is so chosen that when the distance from O to the chain is a minimum, the distance from S to the chain is a maximum, and vice versa. Fig. 4 is the same as Fig. 3, except that the chain rollers have been advanced through a distance of one-half the pitch. For the position shown in Fig. 3, the speed of the driven wheel is a minimum, the velocity ratio being $\frac{OC}{SB}$. For the position shown in Fig. 4, the speed of the driven wheel is a maximum, the velocity ratio being $\frac{OA}{SE}$.

The variation in the speed of the driven wheel for these two positions equals $(OA \div SE) - (OC \div SB)$.

The ratio of this variation to the minimum speed equals

$$\frac{(OA \div SE) - (OC \div SB)}{OC \div SB}$$

The percentage of variation equals

$$100 \times \left(\frac{OA \div SE}{OC \div SB} - 1 \right) =$$

$$\frac{100}{(OC \div SB)(SE \div OA)} - 100 =$$

$$\frac{100}{(OC \div OA)(SE \div SB)} - 100 =$$

$$\frac{100}{\cos \frac{180°}{n} \times \cos \frac{180°}{N}} - 100 \qquad (1)$$

In Fig. 5 the center distance is such as to make the chain span an exact multiple of the pitch. In this case the speed of the driven wheel varies between $\frac{OA}{SB}$ as a maximum and $\frac{OC}{SE}$ as a minimum. (Dimensions OC and SE correspond to those in Figs. 3 and 4.)

The variation in the speed of the driven wheel $= \frac{OA}{SB} - \frac{OC}{SE}$.

The ratio of this variation to the minimum speed equals

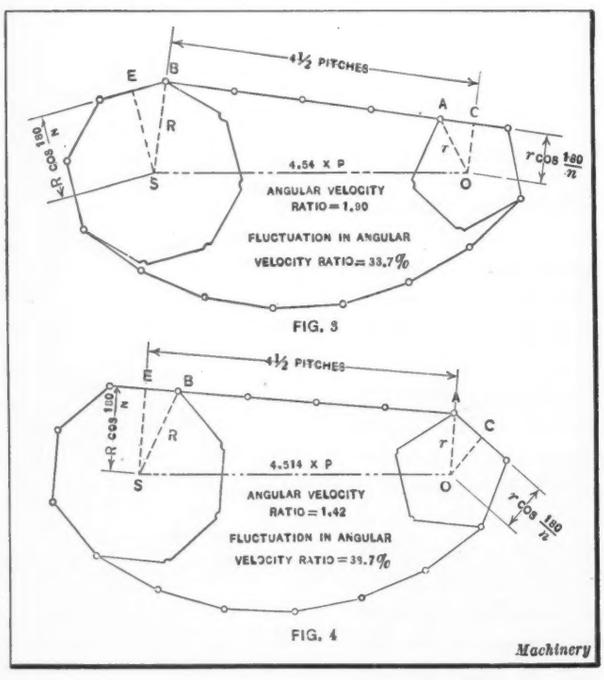
$$\frac{(OA \div SB) - (OC \div SE)}{OC \div SE}$$

The percentage of variation $= 100 \times \left(\frac{OA \div SB}{OC \div SE} - 1 \right)$

$$= 100 \times \left(\frac{SE \div SB}{OC \div OA} - 1 \right) = 100 \times \left(\frac{\cos (180° \div N)}{\cos (180° \div n)} - 1 \right) \qquad (2)$$

Relation between Velocity Changes and Efficiency of Chain Drives

The accompanying table shows the percentages of variations in angular velocity for various combinations of teeth. The upper figures (calculated from Formula 2) represent



Figs. 3 and 4. Diagrams illustrating Two Cases in which the Center Distance is Such as to produce a Maximum Variation in Angular Velocity

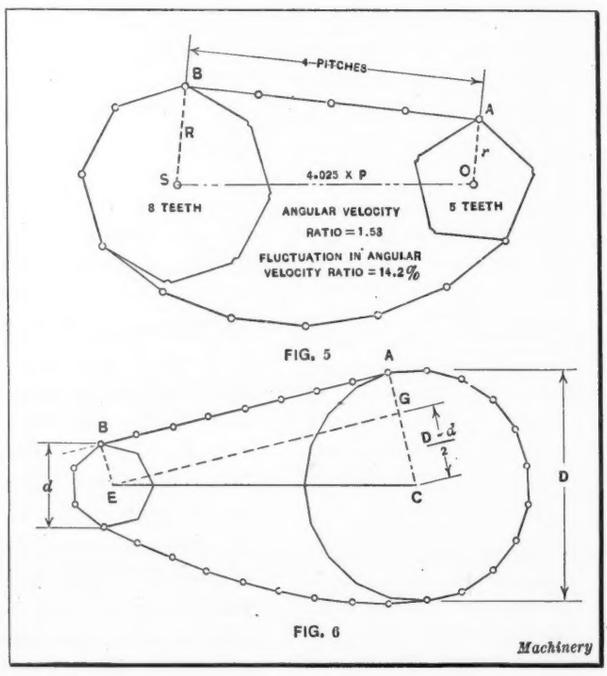


Fig. 5. Center Distance which makes Span AB of Chain an Exact Multiple of the Pitch. Fig. 6. Factors Required when calculating Center Distance for Highest Efficiency

TABLE GIVING PERCENTAGES OF VARIATION IN SPROCKET SPEED FOR VARIOUS COMBINATIONS OF TEETH

No. of Teeth on Larger Wheel	No. of Teeth on Smaller Wheel														
	6	8	9	10	12	14	15	16	18	20	24	30	36	48	60
6	00.0 33.3														
7	4.0 28.2														
8	6.7 25.0	00.0 17.0													
9	8.5 22.9	1.7 15.0	00.0 13.0						Combinations allowable only when center distances are properly adjusted for reducing velocity fluctuations.						
10	9.8 21.4	2.9 14.0	1.2 12.0	00.0 11.0											
12	11.5 19.5	4.6 12.0	2.8 10.0	1.6 8.9	0.0 7.2										
14	12.6 18.4	5.5 11.0	3.7 9.2	2.5 7.8	0.9 6.2	0.0 5.2									
15	13.0 18.1	5.9 11.0	4.1 8.8	2.8 7.5	1.3 5.8	0.3 4.9	0.0 4.5								
16	13.3 17.7	6.2 10.0	4.4 8.5	3.1 7.2	1.5 5.6	0.6 4.6	0.3 4.2	0.0 4.0							
18	13.7 17.2	6.6 9.9	4.8 8.1	3.6 6.8	2.0 5.1	1.0 4.2	0.7 3.8	0.4 3.5	0.0 3.1						
20	14.1 16.9	6.9 9.6	5.2 7.7	3.8 6.5	2.2 4.8	1.3 3.8	1.0 3.5	0.7 3.2	0.3 2.8	0.0 2.5					
21	14.3 16.6	7.0 9.4	5.3 7.5	4.0 6.2	2.4 4.6	1.4 3.6	1.1 3.3	0.8 3.0	0.4 2.6	0.1 2.4			Speed variation reduced from 1 to 2½ per cent by proper center adjustment.		
24	14.5 16.5	7.3 9.2	5.5 7.3	4.3 6.0	2.7 4.4	1.7 3.5	1.4 3.1	1.1 2.8	0.7 2.4	0.4 2.2	0.0 1.7				
28	14.7 16.2	7.6 9.0	5.7 7.1	4.5 5.8	2.9 4.2	1.9 3.3	1.6 2.9	1.3 2.6	0.9 2.2	0.6 2.0	0.2 1.5				
30	14.8 16.1	7.6 8.8	5.8 7.0	4.6 5.7	3.0 4.1	2.0 3.1	1.7 2.8	1.4 2.5	1.0 2.1	0.7 1.8	0.3 1.4	0.00 1.10			
32	14.9 16.0	7.7 8.7	5.9 6.9	4.7 5.6	3.1 4.0	2.1 3.0	1.8 2.7	1.5 2.5	1.1 2.0	0.8 1.7	0.4 1.3	0.10 1.00			
36	15.0 15.9	7.8 8.6	6.0 6.8	4.7 5.5	3.1 3.9	2.2 3.0	1.8 2.6	1.6 2.4	1.2 1.9	0.9 1.6	0.5 1.3	0.20 1.00	0.00 0.77		
40	15.1 15.8	7.9 8.6	6.1 6.8	4.8 5.5	3.2 3.8	2.3 2.9	1.9 2.6	1.7 2.3	1.2 1.9	0.9 1.6	0.5 1.2	0.25 0.87	0.10 0.69		
42	15.2 15.8	7.9 8.5	6.1 6.8	4.9 5.4	3.3 3.8	2.3 2.8	2.0 2.5	1.7 2.2	1.3 1.8	1.0 1.5	0.6 1.2	0.30 0.81	0.15 0.63		
48	15.2 15.7	8.0 8.4	6.2 6.7	5.0 5.3	3.4 3.7	2.4 2.7	2.1 2.4	1.8 2.2	1.4 1.7	1.0 1.4	0.7 1.1	0.35 0.75	0.20 0.57	0.00 0.43	
60	15.3 15.6	8.1 8.4	6.3 6.6	5.0 5.3	3.4 3.7	2.4 2.7	2.1 2.4	1.8 2.1	1.4 1.7	1.1 1.4	0.7 1.0	0.40 0.69	0.25 0.52	0.08 0.35	0.00 0.27

Combinations which are bad under any condition.

These combinations are good, and little is gained by adjustment of centers for reducing velocity fluctuations.

the percentages of variation in the angular velocity of the driven wheel when the span of the chain is an exact multiple of the pitch, and the lower figures (calculated from Formula 1) represent the percentages of variation when the span is an odd multiple of one-half the pitch. Tests of a drive in which 14 and 14 teeth were used, showed that the efficiency was increased 5.6 per cent by changing from 30¾-inch centers to 30-inch centers, the pitch being 1½ inches. The same test made with equal sprockets of 64 teeth showed an increase in efficiency of 0.5 per cent. These figures are so close to those given in the table as to be significant, and assuming a probable error of at least 0.3 per cent in the results of these efficiency tests, we might conclude that the approximate gain in efficiency due to a proper adjustment of centers is as follows:

Percentage of gain in efficiency equals

$$\frac{100 \times \sin\ (180° \div N) \times \tan\ (180° \div N)}{\cos\ (180° \div n)}$$

This is the difference between Formulas (1) and (2).

Four General Classes of Tooth Combinations

Assuming that a speed variation of more than 3 per cent is undesirable and that a 1 per cent reduction in speed variation is worth considering, an examination of the table referred to will enable us to divide all tooth combinations into four classes, as indicated by the division lines.

Class 1—The following combinations are bad under any condition:

6 teeth combined with 7 or more teeth
8 teeth combined with 12 or more teeth
9 teeth combined with 14 or more teeth
10 teeth combined with 16 or more teeth
12 teeth combined with 30 or more teeth

Class 2—The following combinations of teeth are allowable only when the center distance is properly adjusted:

6 teeth combined with 6 teeth
8 teeth combined with 8 to 10 teeth
9 teeth combined with 9 to 12 teeth
10 teeth combined with 10 to 15 teeth

12 teeth combined with 12 to 28 teeth
14 teeth combined with 14 to 30 teeth
15 teeth combined with 15 to 24 teeth
16 teeth combined with 16 to 21 teeth
18 teeth combined with 18 teeth

Class 3—The following combinations are allowable without special adjustment of centers, but if centers are properly adjusted there will be a reduction of from 1 to 2.5 per cent in speed variation:

15 teeth combined with 28 to 30 teeth
16 teeth combined with 24 to 30 teeth
18 teeth combined with 20 to 30 teeth
20 teeth combined with 20 to 30 teeth
24 teeth combined with 24 to 30 teeth
30 teeth combined with 30 teeth

Class 4—The following combinations are good, and very little is gained by an adjustment of centers for reducing fluctuations in angular velocity: 14 or more teeth combined with 31 or more teeth.

Thus it appears from the foregoing that a pair of sprockets with 9 and 12 teeth having the center distance properly adjusted produces less speed variation than a pair of sprockets that have 15 and 20 teeth and improper center distance.

Calculating Center Distance for Highest Efficiency

If line *EG* (see diagram Fig. 6) is drawn parallel to the tight side *BA* of the chain, and *CA* and *EB* are each perpendicular to *BA*, then *ECG* will be a right triangle, and

$$EC = \sqrt{GE^2 + CG^2} = \sqrt{AB^2 + \frac{(D-d)^2}{4}}$$

$$= \tfrac{1}{2}\sqrt{4 \times AB^2 + (D-d)^2} \qquad (3)$$

where D and d are the pitch diameters of the two sprockets and the span AB is an exact multiple of the pitch.

Example—Suppose it is proposed to install a chain drive with sprockets having 24 and 14 teeth, 2-inch pitch, and a center distance of about 14½ inches which is capable of being changed slightly. What is the nearest center distance to 14½ inches that will make the span of the chain an exact multiple of the pitch?

Solution—In Fig. 6 AB is evidently a little less than the center distance, and since it must be a multiple of the pitch which is 2 inches, its value must be taken as 14. Then,

$4 \times AB^2 = 4 \times 196 = 784$; $D = 15.323$; and $d = 8.988$

$$\text{The sprocket pitch diameter} = \frac{\text{Pitch of chain}}{\sin\ (180^\circ \div \text{No. of teeth})}$$

Therefore in this example,

$$EC = \tfrac{1}{2}\sqrt{784 + 40.132} = 14.354 \text{ inches}$$

Hence, if the center distance is exactly 14.354 inches, the span of the chain will be exactly 14 inches or 7 pitches, and the variation in angular velocity will be a minimum.

Center Distance Based on Maximum Uniformity of Sprocket Speed and Minimum Slack in Chain

Now the effect of this careful adjustment of centers is generally to introduce an extra amount of slack in the non-driving strand of the chain. We will therefore investigate the conditions under which it is possible to obtain the minimum variation in angular velocity and at the same time eliminate the slack in the non-driving strand of the chain.

Let n = number of teeth in smaller sprocket;
N = number of teeth in larger sprocket;
P = pitch;
d = pitch diameter of a sprocket with n teeth of 1-inch pitch;
D = pitch diam. of sprocket with N teeth of 1-in. pitch;
M = angle included between the line of centers and either strand of the chain;
K = an integer, the value of which depends upon conditions as explained later.

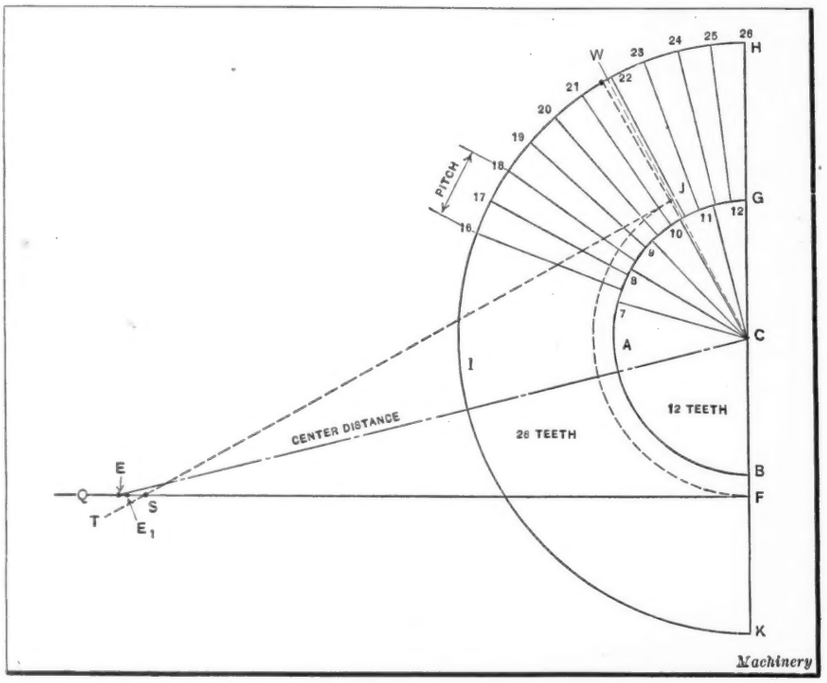


Fig. 7. Graphical Method of determining Center Distance for Maximum Uniformity of Sprocket Speed and Minimum Slack

In addition, x and y are to equal, respectively the numerator and denominator of the fraction $\frac{n}{N}$ when reduced to its lowest terms.

Thus, if $n = 14$ and $N = 35$, $\frac{n}{N} = \frac{14}{35} = \frac{2}{5}$, then $x = 2$, and $y = 5$.

Case 1—If $N - n$ is *even*, and $y - x$ is *odd*, then the angle M can be any multiple of $\frac{180x}{n}$ degrees, except that sin M must not exceed $\frac{D_1 - d_1}{D_1 + d_1}$, where D_1 and d_1 are outside diameters of the two sprockets. When this value of sin M is reached the sprockets will touch each other.

Case 2—If the conditions do not fall within Case 1, the angle M will be an *odd* multiple of $\frac{90x}{n}$ degrees; but sin M must not exceed $\frac{D_1 - d_1}{D_1 + d_1}$.

Example of Case 1: $n = 16$; $N = 24$; $x = 2$; $y = 3$.
Example of Case 2: $n = 18$; $N = 30$; $x = 3$; $y = 5$.

The span of the chain in pitches will be the integer nearest to the value obtained by the following formula:

$$\text{Span in chain pitches} = \frac{1}{2P}(D - d)\ \cot M \qquad (4)$$

where M is $\frac{180x}{n}$ degrees multiplied by 1, 2, or 3 for Case 1, and $\frac{90x}{n}$ degrees multiplied by 1, 3, or 5 for Case 2.

The center distance in pitches equals

$$\sqrt{(\text{Span, in pitches})^2 + \frac{1}{4P^2}(D - d)^2} \qquad (5)$$

The chain length in pitches equals

$$2 \times \text{Span, in pitches} + \frac{N+n}{2} + \frac{K\,(y-x)}{2} \qquad (6)$$

where K is either 1, 2, or 3 for Case 1 and either 1, 3, or 5 for Case 2.

Example—Let it be required to find all of the center distances for a chain drive in which the velocity variations will be a minimum with no slack in the non-driving strand of the chain, where the sprockets have 13 and 26 teeth, and the pitch is 2 inches. Then $\frac{n}{N} = \frac{13}{26} = \frac{1}{2}$; $x = 1$; and $y = 2$.

Since $N - n$ is odd, the problem comes under Case 2. The pitch radii of the sprockets are 8.2965 and 4.1785 inches, respectively; therefore

$$\text{Span} = \frac{1}{2 \times 2} \times (16.593 - 8.357) \times \cot \frac{90 \times 1}{13}$$

$$= 2.059 \cot 6 \text{ deg. } 55 \text{ min. } 23 \text{ sec.}$$

$$= 2.059 \times 8.2357 = 16.95$$

$$= 17 \text{ pitches}$$

$$\text{Center distance} = \sqrt{17^2 + \frac{1}{4 \times 4} \times 8.236^2} = 17.124 \text{ pitches}$$

$$= 17.124 \times 2 \text{ or } 34.248 \text{ inches}$$

$$\text{Chain length} = 2 \times 17 + \frac{26+13}{2} + \frac{1(2-1)}{2} =$$

$$34 + 19.5 + 0.5 = 54 \text{ pitches} = 108 \text{ inches}$$

If a second solution is possible, the angle M will be 3×6 degrees 55 minutes 23 seconds; or 20 degrees 46 minutes 9 seconds, and its sine will be less than $\frac{D_1 - d_1}{D_1 + d_1}$. Sin 20 degrees 46 minutes 9 seconds = 0.3546 and $\frac{D_1 - d_1}{D_1 + d_1} = 0.3095$. Hence a second solution is not possible.

Graphical Method of Determining Center Distances

With any point C as a center (Fig. 7) draw the two half pitch circles GAB and HIK. Divide the smaller semicircle into n equal parts and the larger semicircle into N equal parts. Number these points of division consecutively in reverse order beginning with H and G. From these points of division draw radial lines as shown, toward the center C, filling about one-third of the semicircles. Note where two even numbered or two odd numbered radii coincide, or nearly coincide. (Pay no attention to coincident lines which are not both odd or both even numbered.) On such a coincident pair of radii lay off a distance WJ equal to the radius of the smaller circle and draw JT perpendicular to WC. Lay off KF equal to WJ and draw FQ perpendicular to HK. Measure FS and take a point E on FQ as near S as possible, but such that FE will be an exact multiple of the pitch. This point E will be the center of the smaller sprocket, and EC will be the center distance, *provided* the radii, such as C-10 and C-22 actually coincide.

If these radii do not exactly coincide, move the point E toward F a distance equal to one-quarter of the sum of the distances between the radii, as measured at the inner and outer circles (that is, their distance at 10 and 22 in this case). Then E_1 C will be the correct center distance. There will be as many solutions as there are pairs of like numbered radii that coincide, or nearly coincide—limited, however, by the interference between sprockets with center distances less than the sum of the two radii.

The elimination of all slack in a chain is not of vital importance except in certain cases. Often a reasonable amount of slack produces quieter action and lessens the tendency of the chain to "whip." Wherever the larger sprocket has 30 teeth or less it will pay to give attention to the center distance which makes the span of the chain an exact multiple of the pitch and reduces the fluctuations in angular velocity ratio.

* * *

STRENGTH OF WOODEN CRATES FOR SHIPPING

The United States Forest Service, in its forest products laboratory at Madison, Wis., has made some experiments to determine exactly what construction for crates used for shipping machinery and other products is the strongest

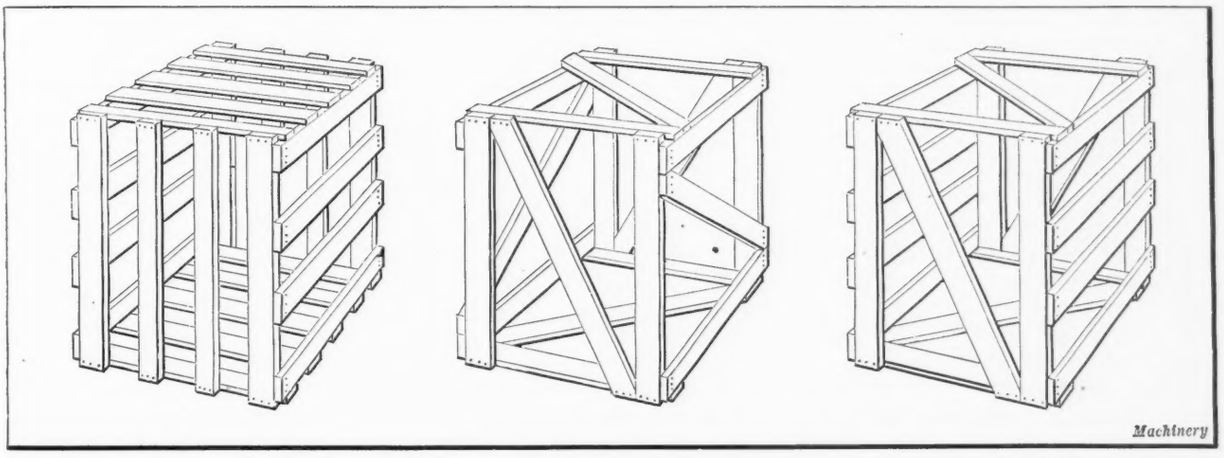


Fig. 1. Crate that is weakly braced

Fig. 2. Crate having Maximum Rigidity

Fig. 3. Combination Diagonal and Parallel Bracing

type and will require the least amount of lumber. The views in the accompanying illustration show three different types of crates. Fig. 1 shows a crate which appears to be very strong, because of the amount of wood used, but tests have shown that crates so braced are weak in the diagonal direction of the faces, and are likely to give trouble during transportation.

The best crate to use, as far as strength is concerned, is that shown in Fig. 2, which has diagonal braces on all six sides, giving the maximum rigidity for a minimum amount of lumber. Crates so braced withstand with considerably less distortion a diagonal compressing force than do crates constructed as in Fig. 1.

The combination of diagonal and parallel slat bracing shown in Fig. 3 makes the crate more rigid than parallel bracing alone, but not so rigid in all directions as cross bracing on the six sides. It may be found an advantageous construction in packing contents which need protection on the sides and are rigid enough themselves to withstand stresses in the direction in which the crate is weak.

* * *

During the first six months of the present year, the loss in wages due to strikes in the state of Pennsylvania alone was $117,500,000, exclusive of the railroad shopmen's strike.

Grinding in the Railroad Industry

Truing Worn Piston-rods—Grinding Guide Bars, Axles, Pins, Valve Gear Links, Slide Valves, and Car Wheels

By the Engineering and Educational Departments of the Norton Co.
Worcester, Mass.

SHOPS belonging to the railroad industry may be divided into three principal classes—those engaged in (1) the manufacture of rolling stock; (2) the repair of rolling stock; and (3) the manufacture of rails, switches, cross-overs and other track equipment. In the manufacture of rolling stock, many of the grinding operations are practically of the same nature as those performed in railroad repair shops, and this article will be confined chiefly to the latter, in view of the fact that most railroad shops are engaged in repairing. On the average, every locomotive in the country is dismantled for repairs once every year. The severe strain upon every moving part either wears or distorts it so that repairs are necessary.

In former years the machining of locomotive parts was thought of as a semi-precision operation. Now, with the advent of the grinding machine, much closer limits can be adhered to with little effort, and this improved quality of workmanship has been obtained, in many instances, in conjunction with greater efficiency. Grinding is applied in the production of new work and in connection with repairs as a means of truing worn surfaces of both hardened and unhardened parts. In performing this truing operation, it is usually essential to remove as little metal as possible, as in the case of piston-rods, links, etc., in order to prolong the life of whatever part is made true by the grinding operation. Grinding is the ideal method of truing such parts as rods, pins, bushings, guide bars, slide valves, links, or other parts that become worn from rubbing or sliding.

Piston-rods wear out of round and shoulders are formed at points representing the limits of travel through the packing. They are usually reground without removing the pistons from the rods. Sometimes the rod is first rough-turned in a lathe, but usually this operation is unnecessary and the rod is ground in one operation on a cylindrical grinding machine. In twenty minutes the whole rod can be finished, removing just enough stock from the diameter to true the rod, which is made round to within 0.0005 inch and with practically no taper. A piston-rod can be repaired in this manner many times before it has to be scrapped, less metal being removed by grinding than by turning and filing. An alundum or some other aluminous abrasive wheel should be used. Ordinarily, a wheel 24 inches in diameter by 3 inches thick, having a grain size of either No. 24 combination or No. 50 (half No. 46 and half No. 60) and grade L in hardness, is satisfactory (Norton grading).

A Norton grinder of the gap type is shown in Fig. 1 truing a piston-rod at the Kingsland shops of the Lackawanna Railroad. In this particular instance, an alundum wheel of grain 6624 and grade K is used. A new end has been welded to this rod, but when the operation is simply that of truing, the piston head is not removed, and then the extra swing obtained with the gap grinder is required.

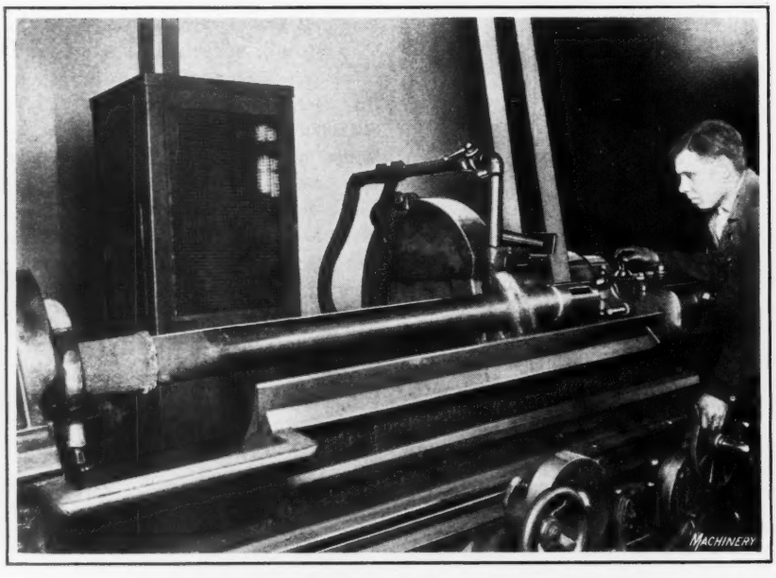


Fig. 1. Retruing a Worn Piston-rod by Cylindrical Grinding

Pin Grinding

Many small cylindrical locomotive parts are ground. Most of them, such as link-block pins and cross-head pins, both tapered and straight, are casehardened and must be ground. Such parts are ground on machines smaller than those used in grinding piston-rods. Aluminous abrasive wheels of grain No. 50 or No. 60 and grade K are employed. This conforms with the theory of "softer wheels for harder material."

Grinding Valve Gear Links

Links for the Walschaert or Stephenson valve motions must be accurately machined in order to obtain proper operation of the valves. By means of a link-grinding machine such as the Hammet or Newton, this can be accomplished readily. The operation of these machines is such that an adjustable radius arm gives the proper circular motion to the links. A Hammet machine is shown in Fig. 2 grinding one section of a link of the assembled type. The arm that controls the circular movements of the

Fig. 2. Grinding One Section of a Reversing Gear Link

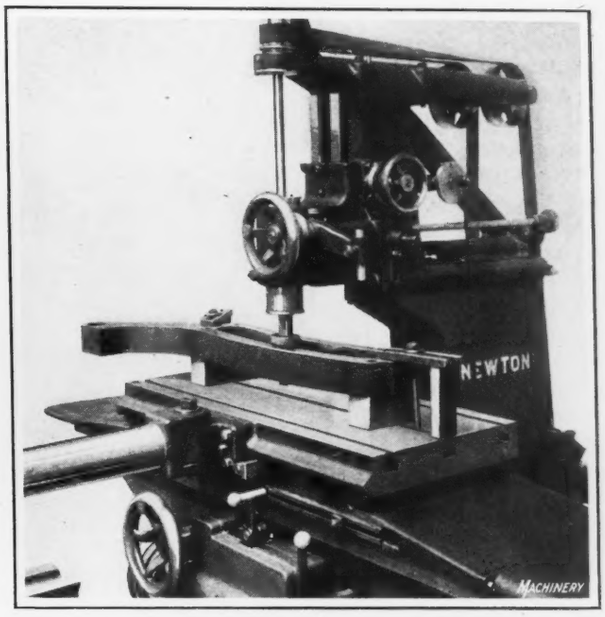


Fig. 3. Another Design of Link-grinding Machine

work-holding table extends out from the front of the machine, and swings about a bearing or pivot, which is adjusted to suit the link radius. The lower section of the work-table operates with a reciprocating motion, and the length of stroke is controlled by adjustable dogs or tappets. Machines of this type are also used for grinding solid or one-piece links which require a small grinding wheel because of the narrow clearance spaces at the ends of the link.

A Newton link-grinding machine is shown in Fig. 3. The circular motion of the work-table is controlled by a pivoted arm as in the machine previously referred to. This pivot or bearing may be adjusted along its supporting rail by a rack and pinion. The spindle slide has a reciprocating motion of ½ inch, which permits using a wide wheel that will cover the entire surface to be ground. When smaller, narrower wheels are required, an intermittent vertical feed may be obtained. The spindle head is adjustable on the upright for regulating the depth of cut. In some railway shops it has been the practice first to plane these "radius-links" on a planer equipped with a radius attachment, and then finish them by draw-filing. This method, however, requires considerable time and is, of course, less accurate than grinding.

Internal Grinding

Holes in such parts as eccentric rod connections, valve motion links, reverse shaft bearings, side-rods, large bushings, etc., are ground most economically on a machine similar to the Heald cylinder grinding machine. In this machine a small wheel is mounted on a spindle which, in addition to rotating on its own axis, also travels in a circular path concentric with the circumference of the hole. The radius of the circular motion can be altered at will, by means of a micrometer adjustment, thus allowing for any size hole within the capacity of the machine. This type of machine allows the work to remain stationary, and is especially adapted for grinding parts that cannot be revolved readily, because of either their shape or size. The grinding of hardened steel bushings in the knuckle joint pin-hole of a connecting-rod illustrates the kind of work that cannot be revolved but is readily ground on a machine of the planetary type. Fig. 4 shows a Heald machine grinding a reverse shaft bearing which is located at one side of a heavy cast-steel bracket.

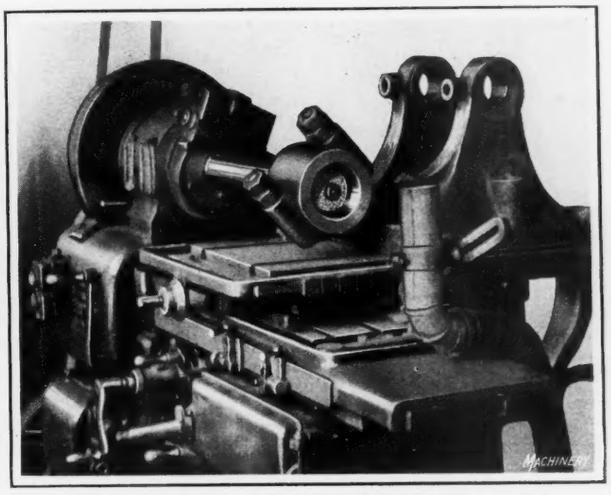


Fig. 4. An Example of Internal Grinding in a Railroad Shop

Surface Grinding Operations

Guide bars which have become worn due to the travel of the cross-head can be trued economically on an open-side type of grinding machine. Fig. 5 shows a Diamond face grinder truing one of these worn guide bars. This particular illustration shows a guide bar 5 feet 9 inches long, and 7 inches wide. About 1/16 inch of stock is removed from the face, and 3/64 inch from the two sides, and the bars are finished at the rate of six in an eight-hour day. This machine will remove about 0.003 inch of stock at each stroke of the table, and the wheel is dressed only twice a day.

Fig. 8 illustrates the use of a face grinder for grinding the sides of connecting-rods. Four of these rods are ground simultaneously by holding them against the face of a large magnetic chuck. By grinding these connecting-rods, the allowance for finishing may be reduced from about ¼ inch to 3/32 inch. Production was also increased from one rod in one hour twelve minutes to four rods in the same time.

Face grinders have proved efficient for many other operations in railroad shops, such as the grinding of slide valves, driving-box shoes, boiler supporting brackets, links, etc. A Bridgeport face grinder is shown in Fig. 6, grinding the sides of a pair of links. This operation is performed after the links have been casehardened. The wheel used in this particular instance is of the sectional type as the illustration shows

In general, the wheels used on face grinders are coarse and rather soft, because the contact area between the wheel and the work is rela-

tively large. The Norton Co. recommends grain No. 14 or No. 16 and grade L alundum for grinding soft steel under average conditions, and the same grain size with grade K crystolon abrasive for cast iron.

Axle journals give the best service when ground cylindrically. The smoother and more accurate any bearing surface is, the less the friction will be, with a resulting improvement in wearing quality. Fig. 7 illustrates the grinding of the journal of a car wheel axle.

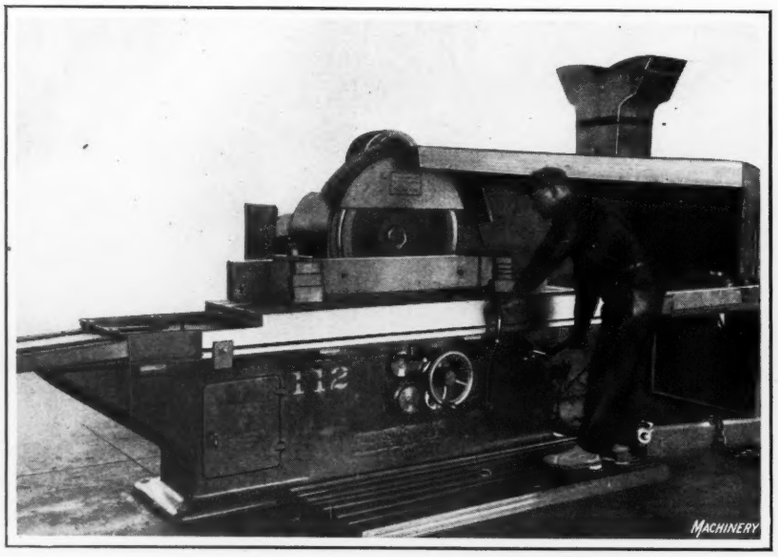


Fig. 5. Truing Worn Surfaces of a Guide Bar on a Face Grinder

Car wheel grinding has always been done to a great extent but as yet not all car wheels are ground. Car wheels in general have soft iron centers with deeply chilled treads. It is economy to grind new wheels to prevent difficulties that arise from wheels being slightly out of round. Used wheels that have developed flat spots are economically salvaged by grinding. Owing to the fact that the metal in this case is cast iron, carbide of silicon instead of aluminous abrasive wheels are used. On the Norton car-wheel grinding machine (Fig. 9) wheels 24 inches in diameter by 4 inches thick are employed in grain sizes from No. 16 to No. 20 and in grades P and Q. Grades P and Q are harder than the grinding wheels ordinarily used on cylindrical grinding machines. They are used because of the type of machine and method of application. The work in this case is not traversed, but the grinding wheel is fed straight in, so that the entire surface of the tread is ground with the full width of the wheel.

The car wheels are usually not removed from their axles before grinding. During the grinding the car axles revolve on their journals rather than on centers. On this account some vibration takes place, which tends to disintegrate the wheel structure, and this, together with the very great pressures applied to hasten the grinding necessitates the use of the very hard wheels mentioned. Steel car wheels are ground with an aluminous abrasive, especially the so-called Davis wheel which has a manganese steel tread with a carbon steel center.

Very little grinding is done on the ordinary steel rail which is turned out in the rolling mill, but cross-overs and frogs and switches are made of manganese steel, owing to

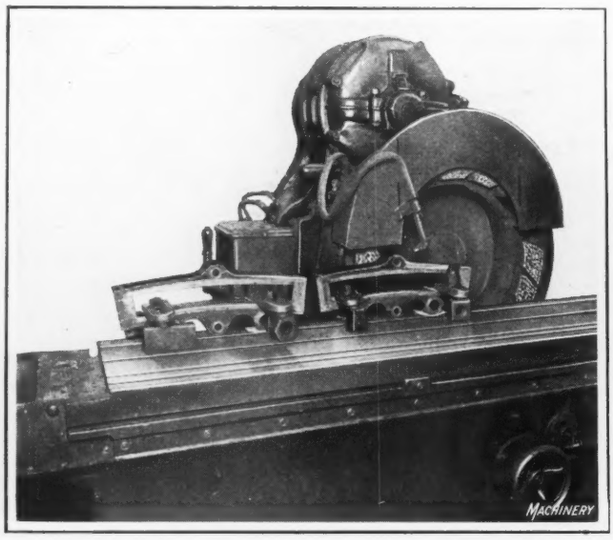


Fig. 6. Grinding the Sides of Links on a Face Grinder

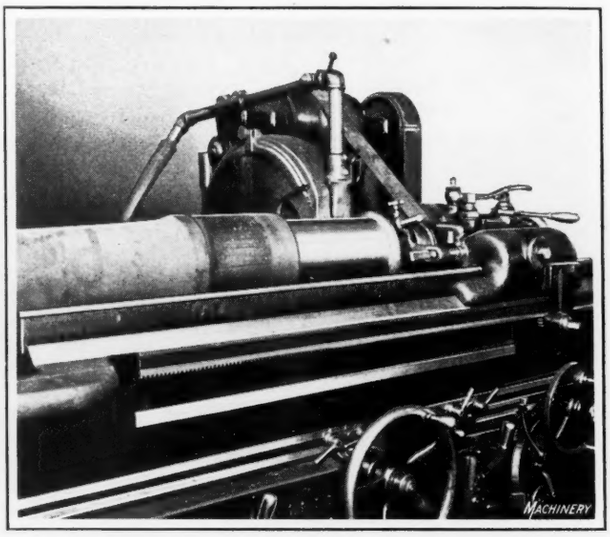


Fig. 7. Finishing the Journal of a Car Wheel Axle by Grinding

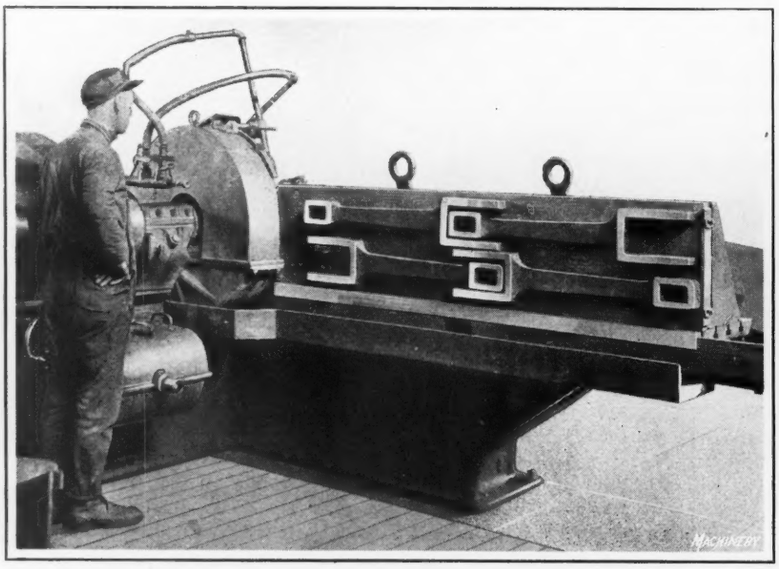


Fig. 8. Face Grinder arranged for grinding Sides of Connecting-rods

the severe use to which they are subjected, and since this metal cannot be machined economically with steel tools, grinding wheels must be used. These manganese steel parts are cast in molds. The first operation, therefore, is to remove the fins, gates and nails, by the use of swing-frame grinding machines (Fig. 10). Frogs and cross-overs are then generally finished on a large planer-type surface grinding machine. The casting is clamped on the table of the machine, and the tops of the rails are surfaced (Fig. 11). The next operation is the grinding of the line or groove in which the flange of the car wheel travels. This groove must be ground to the proper shape and depth. The cross-over is so clamped on the table of the machine that the grooves are in alignment with the table slide, so that the grinding wheel will follow them. A wheel 1¼ inches wide, properly shaped at the face, is generally used. Care must be taken to see that the grooves are ground to the same depth, and that one groove is not ground lower than another at the place of junction at the corners of the cross-over. This prevents jolting when the flange of the car wheel bears on the groove bottom just at the point of crossing.

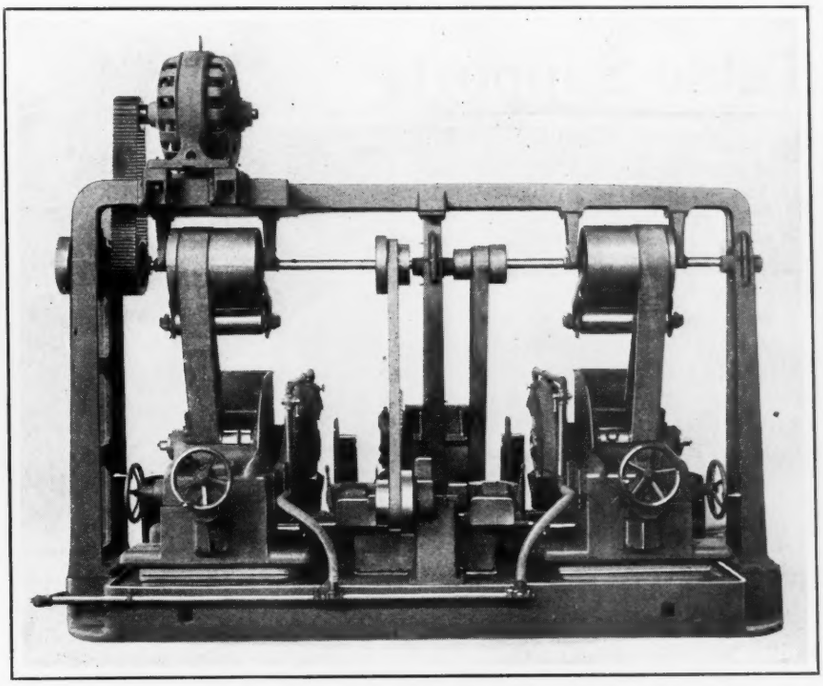


Fig. 9. Duplex Type of Car Wheel Grinder which finishes Entire Surfaces of the Treads as Grinding Wheels are fed in

The sides of the eight ends must be ground smooth so as to make a proper seat for the fish plates (tie plates). The ends are also ground square so that a good butt joint will be made with the rail it ties to. Both of these operations are performed with portable grinding machines of the electric or pneumatic type, having wheels 8 or 10 inches in diameter, or by the use of special precision machines. Often the stubs of large wheels can be utilized for this work. In some plants precision grinding machines are not employed for surfacing and grooving the cross-overs. In such cases the work is done with swing-frame or portable grinding machines. Frogs and switches are likewise machined by grinding.

The limit of the application of the grinding machine in the railroad industries has by no means been reached. Each year adds new operations which formerly were accomplished by steel tools. Grinding wheels, both when used as precision tools and when used as tools for the rapid removal of metal in a rough, offhand method, are of great importance. Their success depends upon an intelligent understanding regarding their use.

* * *

STANDARDIZATION OF ELECTRIC DRILLS

What are believed to be the first standards for portable electric drills were adopted by the Electric Power Club on August 20, and are printed in Bulletin 7900, issued by the club. These rules are the nucleus of a complete group of electric tool standards, and what has already been accomplished includes a definition of what constitutes a portable electric drill, test requirements of the motors, performance specifications for drilling, standard sizes of drills, and the information which should be given on drill name-plates.

Electric drills are now widely used, not only for maintenance work, but also very largely as tools of production. The users of electric tools have felt for some time that these devices should be standardized, and it was to meet this need that the Power Club's Electric Tool Section, comprising the representative portable electric tool manufacturers of the country, has undertaken the work. The electric drill standards will be published in the next edition of the Electric Power Club's Handbook.

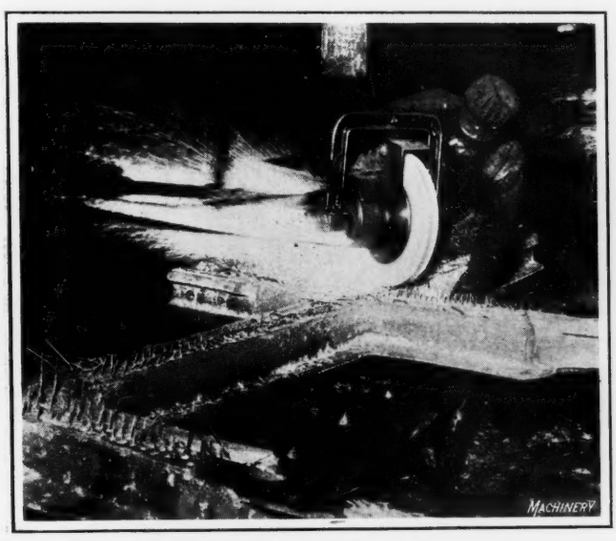


Fig. 10. Snagging a Cross-over by using Swing-frame Grinder

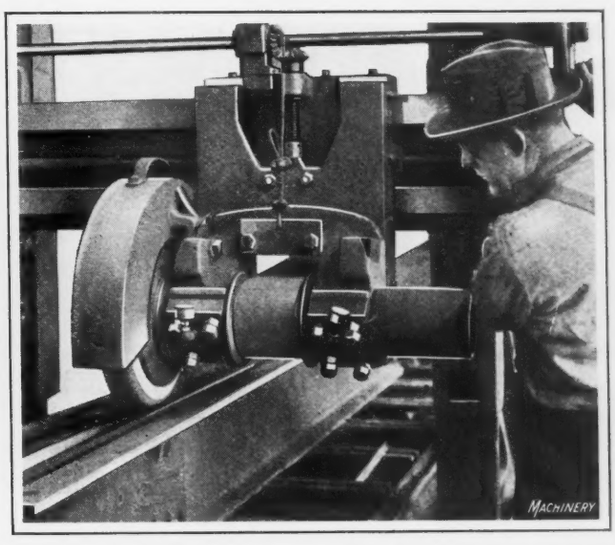
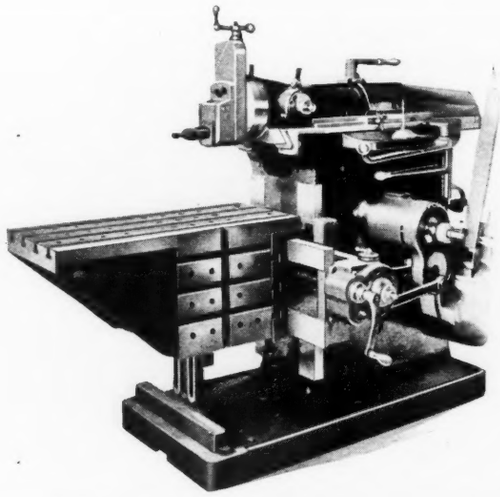


Fig. 11. Grinding Upper Surface of a Street Railway Switch

Shaper Table Supports

Devices Employed by Various Manufacturers to Counteract the Downward Thrust of the Cut

By FRED HORNER



As the shaper has a work-table supported at one end only, like the knee on a milling machine, the tendency of the cutting pressure is to spring the table downward. In the milling machine, braces are added to tie the over-arm to the knee, and often the latter to the base, these provisions compensating largely for the one-sided design of the knee. In the shaper, this provision was neglected, until the introduction of high-speed steels and high production rates forced consideration of this matter.

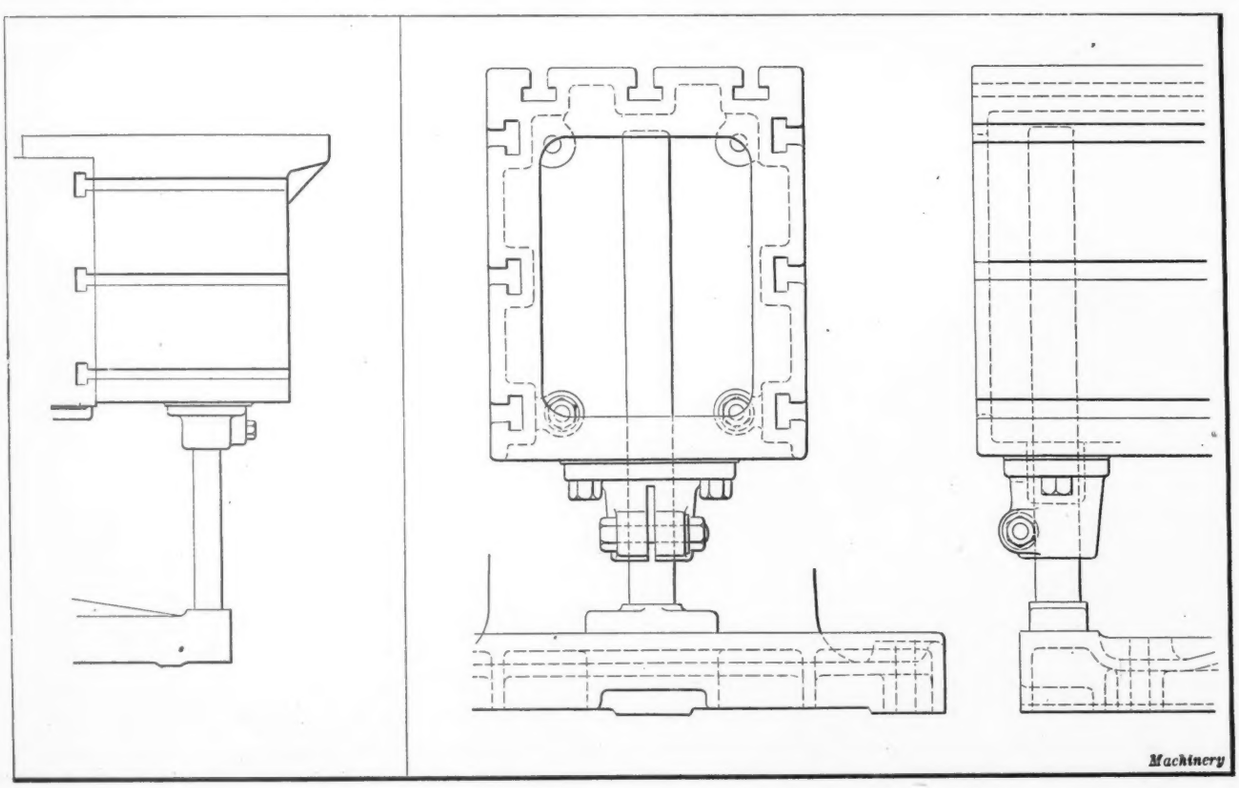
Points to be Considered in Providing a Support

Part of the table deflection due to the pressure of the cut can be prevented by an improved design of the gib arrangements, in which the top gib is of wedge shape, so that additional stresses on the table help to pull it harder against the contact faces. With the draw-cut shaper, the thrust of the tool is directed toward the column, and there the table is pushed against the saddle. But no device entirely prevents deflection so long as the table is unsupported near the extended end, as even the weight of heavy work will produce some deflection before the tool pressure is applied. An additional table support is therefore advantageous, not only to keep the table in the proper position under all circumstances, but also to relieve the saddle cross-rail and fastening devices of unnecessary strain.

The problem of supporting the table of a shaper is not quite the same as supporting the knee of a milling machine, because in the latter case the knee has no lateral movement. The shaper table has a lateral feed, and any support must allow for this movement. In some designs a machined base is furnished on which the support can run, while in others a narrow facing serves this purpose. There is much variety in the arrangements, the sliding action taking place on the base, on a ledge higher up, or on the under side of the table. If rigidity of construction is assured in any type of support, the next important thing is freedom from chips. In some designs where this vital point is neglected, the table is sprung upward by the supporting device riding on chips or grit. A further consideration in designing a support is whether it shall sustain only the downward thrust and the bending tendency, or whether it shall also take care of lateral and upward deflection due to cutting in those directions. Some supports are arranged to meet these conditions.

Simple Forms of Support

A round bar is used as a support on machines built by the Cincinnati Shaper Co., a bracket being attached to the table as shown in Fig. 1. The bar is gripped in this bracket by tightening a screw after the bar has been brought down to rest on the machined surface of the base. In order to



Figs. 1 and 2. Simple Designs of Round-bar Supports for Shaper Tables, provided to eliminate Deflection caused by Overhang of the Table

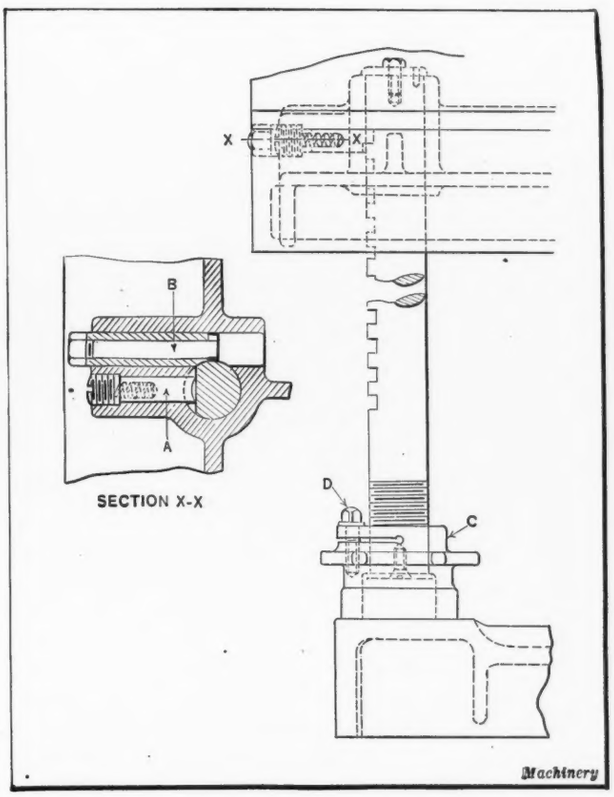


Fig. 3. Construction in which Slipping of the Support is prevented by a Plunger engaging Notches on the Support

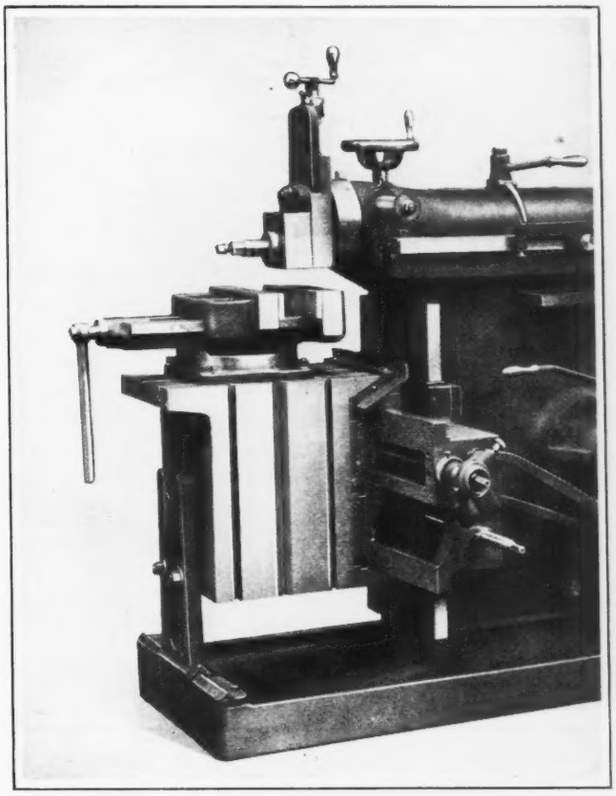


Fig. 4. Bracket Support in which the Lower End slides on a V-shaped Strip attached to the Machine Base

provide a larger sliding surface on the supporting member, some designers prefer a foot, as shown in Fig. 2, which also serves effectively to prevent tilting. The support in Fig. 1 is also often provided with a foot. That in Fig. 2 is found on shapers made by Greenwood & Batley, Ltd., Leeds, England.

The usual practice of holding the supporting bar by friction alone is modified in shapers built by the American Tool Works Co., by having a series of notches and a locking plunger that afford a positive check to slipping. This construction is shown in Fig. 3. Near the bottom of the table a spring plunger *A* engages one of the notches along the bar, and the bar is then held firmly by means of bolt *B* which has a machined surface at the end that engages the bar. Any slight adjustment that may be necessary is made by turning the split nut *C*, which is locked in place by tightening screw *D*. The Smith & Mills Co. also utilizes a bar support, but instead of traveling on the base, it always remains in a central position under the tool, the under side of the table sliding on the cap of the support. The arrangement is shown in Fig. 5. The machine base is recessed at the front, and a bracket is mounted on machined surfaces on each side. A sleeve set into a bearing at the top of the bracket permits vertical adjustments of the bar. This sleeve may be clamped in any required position.

Designs in which Brackets are Employed

In many instances a bracket of rectangular cross-section is substituted for the bar support, the bracket construction

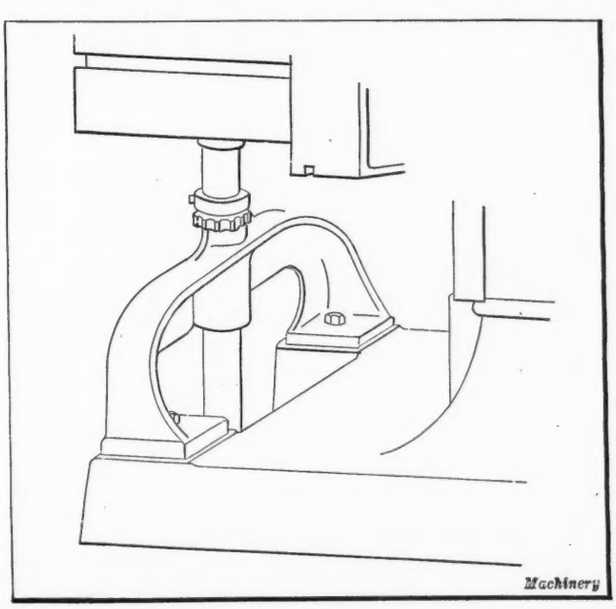


Fig. 5. Example in which the Supporting Bar extends through a Sleeve in a Bracket mounted on the Base of the Machine

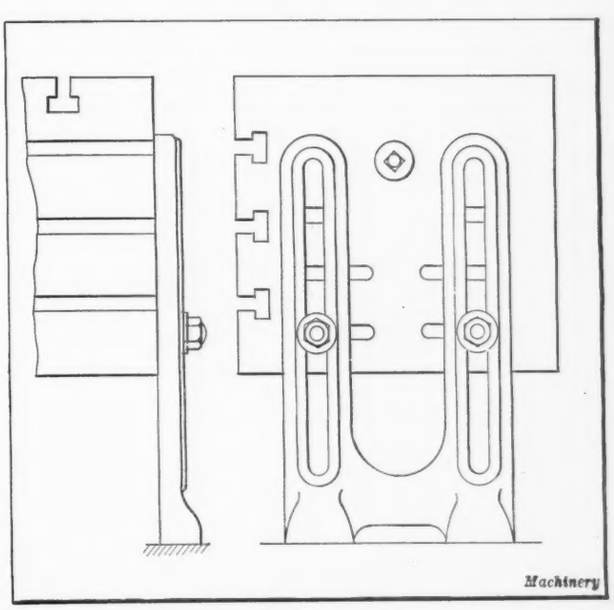


Fig. 6. Support for Shaper Table consisting of an Upright Bracket having Two Feet and Two Slots for Clamping Bolts

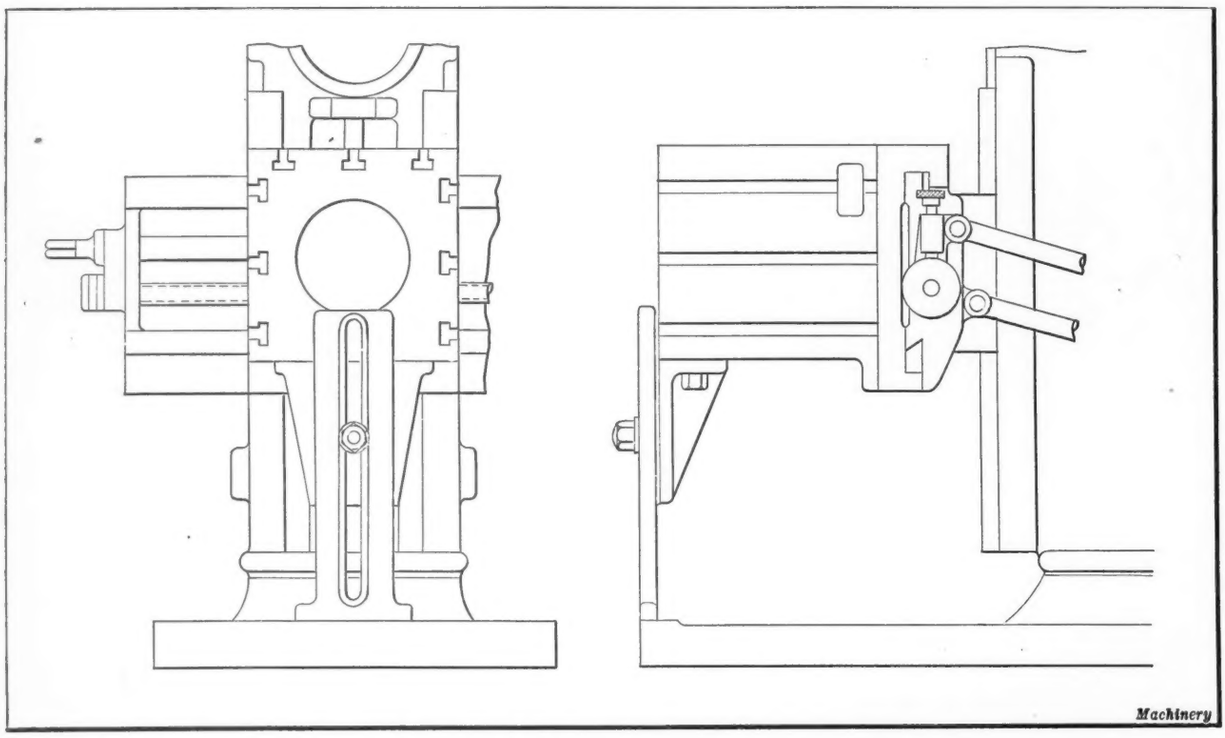


Fig. 7. Design in which the Upright is attached to an Angle-bracket fastened to the Under Side of the Shaper Table

being used to resist twisting stresses on the table. Sometimes this design is adopted in order to obtain an increased area of the wearing surfaces. Methods of jointing the bracket and table together vary. Some bracket supports are bolted directly to an ordinary table without any special provision for the purpose, while in other cases slots, surfaces, or apertures are machined for the support. Fig. 6 illustrates a plain two-slot bracket bolted to the front of the table on a large traversing-head machine built by Henry Holmes & Co., Halifax, England. This bracket has two feet. A similar example, but with a V-shaped foot having felt pads and sliding on a V-strip on the base is shown in Fig. 4. This design is found on shapers made by the John Bertram & Sons Co., Dundas, Ontario, Canada. The arrangement shown in Fig. 7, which transfers the clamping position from the front to the under side of the table, is a feature of the machines made by the Ormerods Tool Co., Ltd., Hebden Bridge, England. The angle bracket materially stiffens the slotted upright.

Giving the upright an inside location offers a slight advantage by leaving the front of the table practically clear. The Oldfield & Schofield Co., Ltd., Halifax, England, follows this method. From Fig. 8 it will be observed that the support extends through the bottom of the table and is clamped, by means of a T-slot and bolt, to an angle bracket attached to the table.

On Gould & Eberhardt shapers a lug is cast on the under side of the table as shown in Fig. 10. A finished surface on this lug affords a seat for the support, but instead of the latter being situated near the front of the table, a midway location is selected, so that the support will sustain much of the weight ordinarily placed on the cross-rail. The slotted upright has a series of serrations on each side of the opening and is fastened to the table lug by means of a stud bolt and a member which engages the serrations. Final adjustment for height is effected by set-screw *A*. The machine base projects well forward and has T-slots for holding certain classes of work.

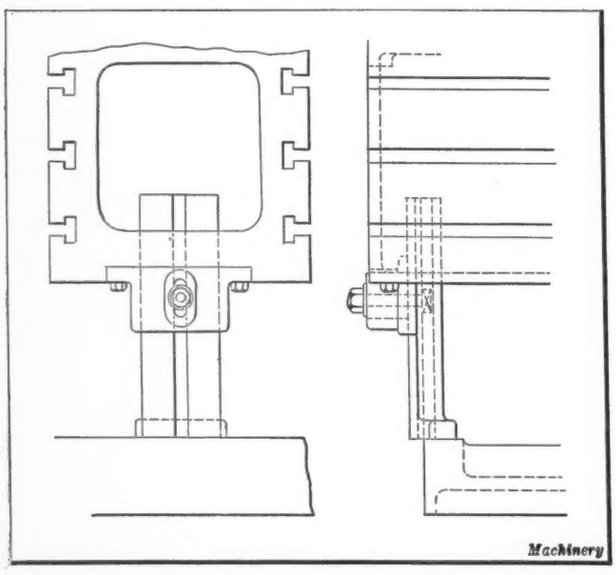


Fig. 8. Support extending into the Table so as to leave the Front Free from Obstruction

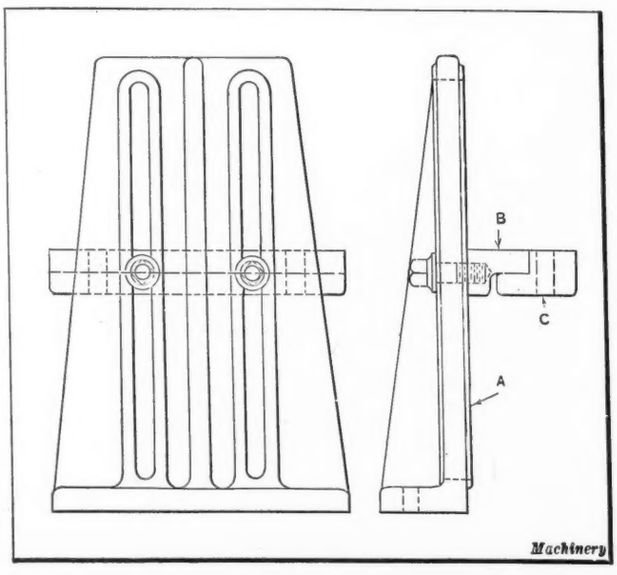


Fig. 9. Details of a Design which prevents both Lifting and Twisting of a Shaper Table

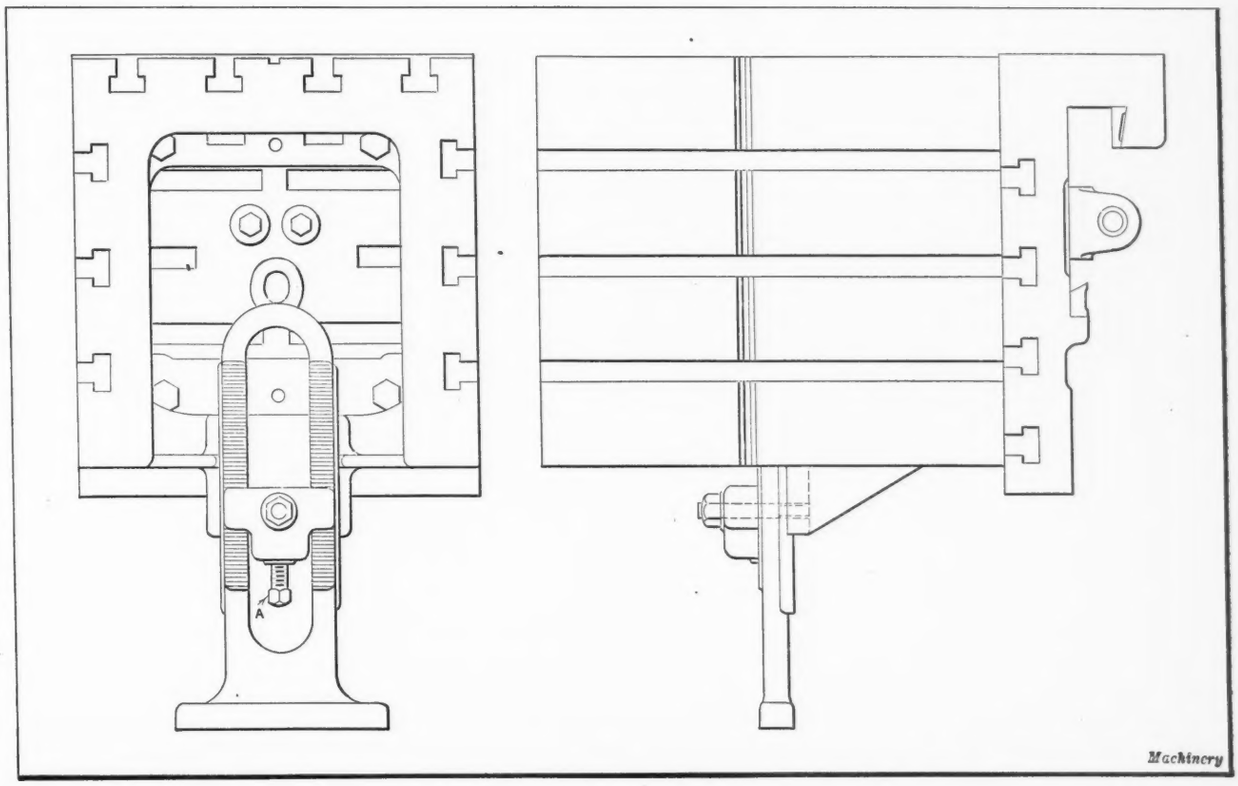


Fig. 10. Construction in which the Support is placed Approximately Midway beneath the Table so that it sustains a Considerable Part of the Weight ordinarily borne by the Cross-rail

The tables of Hendey shapers are also supported at about the center through the use of an angle bracket and a double-slotted upright, but instead of sliding the foot of the upright upon an exposed surface, a special channel-shaped guide is provided, as shown in the heading illustration. The top lip of this guide acts as a guard against dirt and chips. The table in this view has an extension doweled and bolted to the front end to accommodate long work.

Sliding Surfaces at Other Locations than at the Base

The sliding face on the base is avoided in several designs by having an inverted strip slide on a bracket attached to a fixed support bolted to the machine base. One such arrangement is illustrated in Fig. 11, the short angle-bracket *A* supporting the longer one *B* which is bolted to the table. In order to prevent the lifting or twisting of the table, the addition of a strip to resist such deflection is occasionally found advisable. The Streine Tool & Mfg. Co. employs the design illustrated in Fig. 9, which consists of the upright *A*, bearing strip *B*, and slide *C*. On the Queen City shapers a similar result is obtained by having a finished projecting lip at the bottom corner of the table, as shown in Fig. 12, and gibbing the slide casting to it. This prevents lateral or upward displacements and guards against chips.

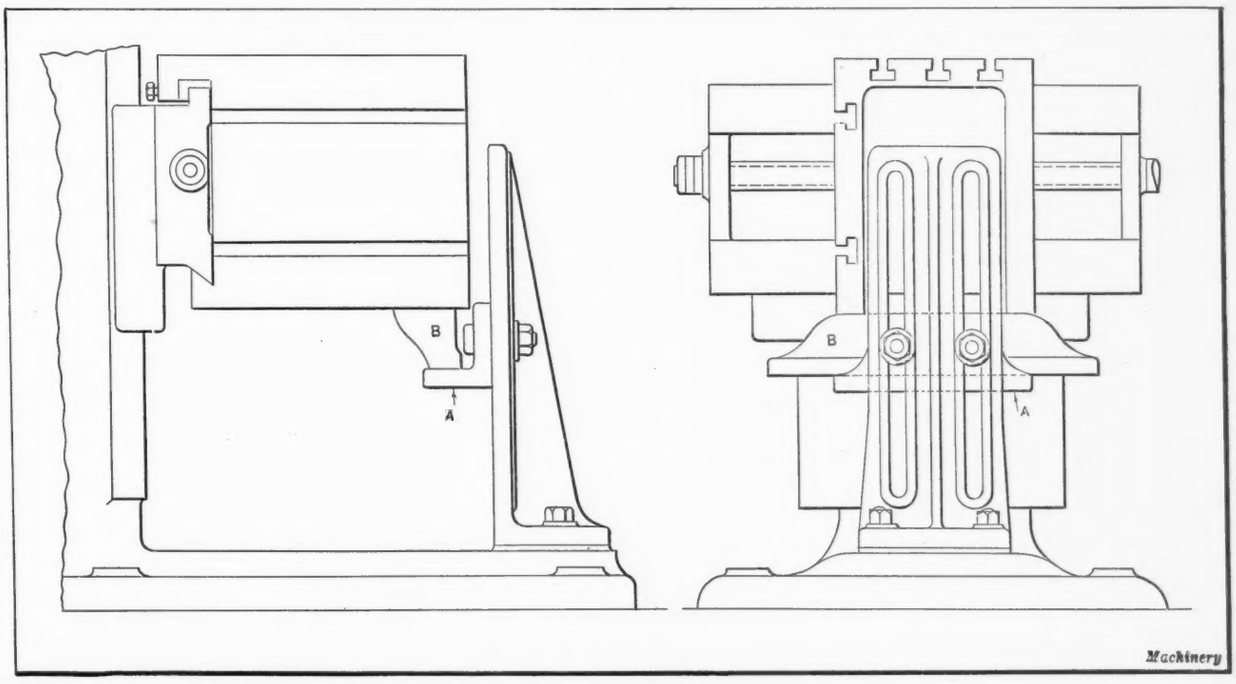


Fig. 11. An Example in which the Sliding Surface of the Support is brought close to the Under Side of the Table

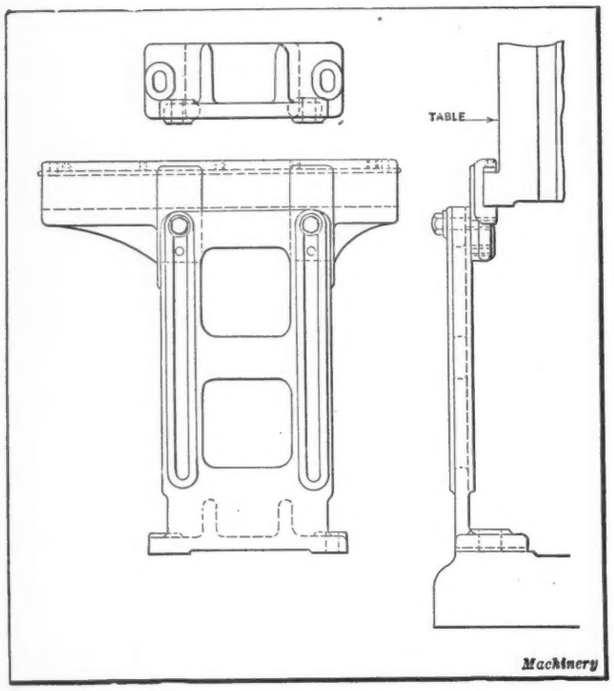


Fig. 12. Support having a Casting at the Upper End that is gibbed to a Machined Lip on the Table

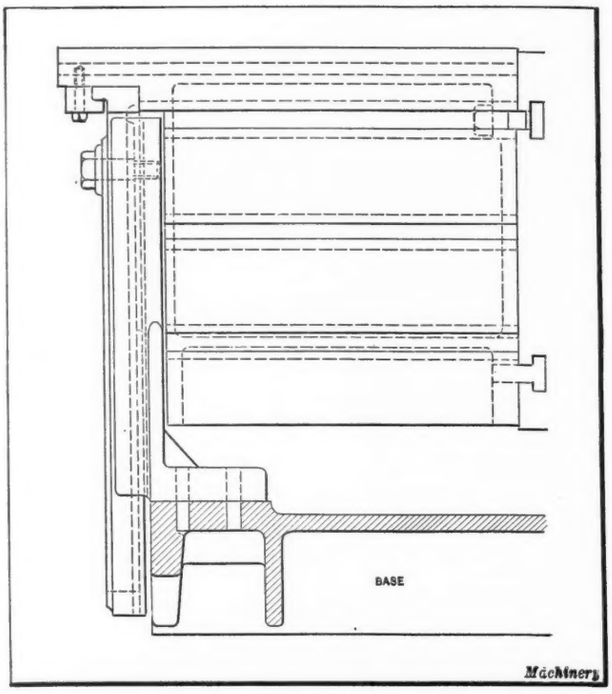


Fig. 13. Table supported by Means of an Overhanging Ledge at the Top near the Front End

Fig. 13 shows a radical difference in the location of the bearing surfaces, the adjustable section of the support reaching right up under the overhanging lip at the top of the table and being gibbed with a strip the full width of the table. This design is found on the larger sizes of machines constructed by the Davis Machine Tool Co. The smaller machines have the angular support illustrated in Fig. 14, which is bolted by means of two spreading feet to the cross-rail, and held rigid by a central foot which is supported on a vertical face on the column.

Supports provided with Rollers

Rolling contact is utilized only to a limited extent for the moving surfaces of shaper supports, and the choice varies between protected rollers on the foot and an inverted arrangement under the table edge. The simple design at *A*, Fig. 15, which is intended for a small shaper, is defective, because the roller rides over chips falling in its path. An end view of the roller is shown at *C*. By placing the roller under the table edge, the trouble from chips may be avoided. Several firms adopt this latter construction, including the Whipp Machine Tool Co., and the Steel Products Engineering Co. Such a design is shown at *B*, in which a well-ribbed bracket is bolted to the base, this bracket having a vertical slot through which passes the clamping bolt of the roller bracket. Some of the Morton draw-cut shapers have a roller bearing support traveling on a machined surface on the base, but protection is insured by felt wipers. This is also the case with the design shown in Fig. 16 in which the use of two rollers provides a good broad base. This type of support is employed on the machines manufactured by the Selson Engineering Co.

Supports for Swiveling Tables

Tables which have a swivel adjustment cannot be employed in conjunction with supports of the types hitherto illustrated, some extra provision being necessary to allow for swiveling. If the table revolves on a pivot extending to the front of the table, the support may be clamped to this pivot, but if there is no such pivot, the upper part of the steady bracket must be made with circular slots to correspond with similar T-slots on the table front.

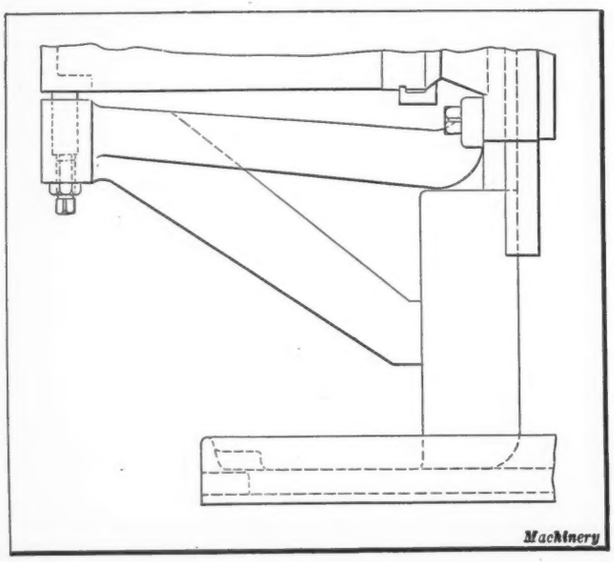


Fig. 14. Table Support having Two Spreading Feet bolted to the Cross-rail and a Central Foot that carries the Load

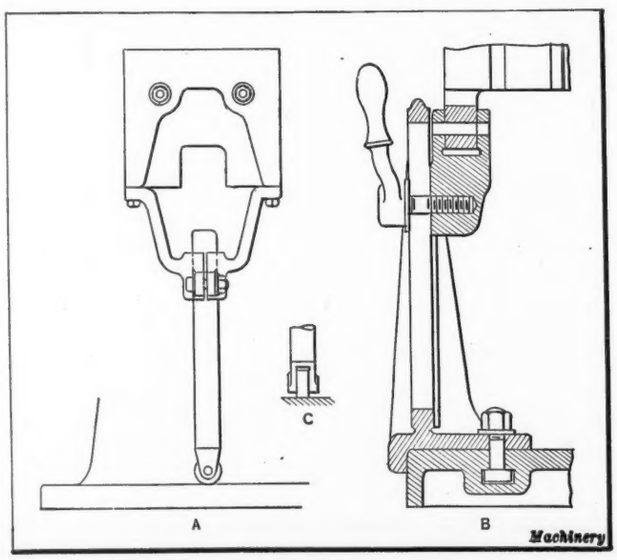


Fig. 15. Two Designs of Table Supports in which Rollers are employed instead of Sliding Members

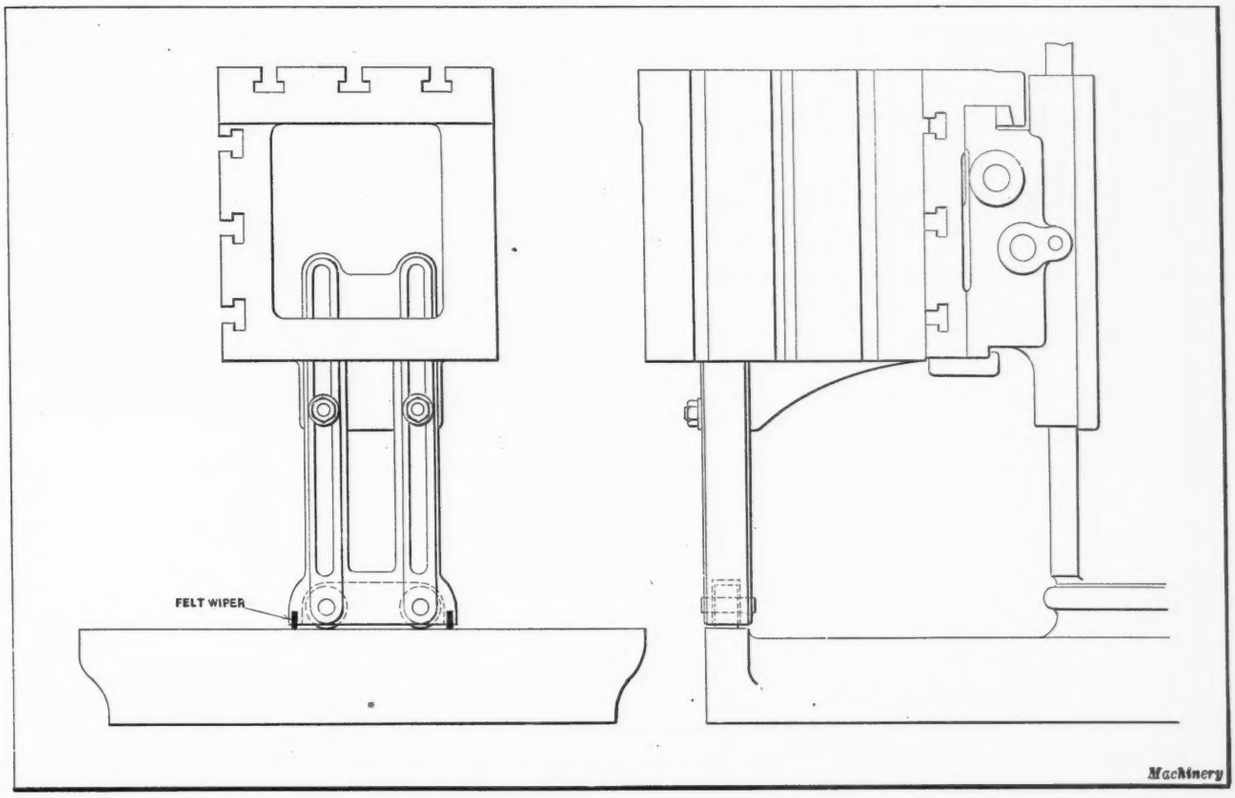


Fig. 16. A Double-roller Support in which Felt Wipers are provided at Each End to keep the Path of the Rollers Free from Dirt and Chips

Two or three bolts in these circular slots would enable adjustments to be made. The shapers made by the R. A. Kelly Co. are equipped as shown in Fig. 17. The plate *B* enables the table to be rotated 40 degrees each side of the vertical, the plate having a bearing edge that slides upon clamp *C*. The latter is secured at a suitable height on upright *A*. Plate *B* consequently remains level at all times, while the table can be swiveled after the bolts in the curved slots have been loosened. There are slots cut on the back of the upright which guide the tongues of the clamping strip; the latter has a ledge at *D* that prevents dirt and chips from falling on the sliding faces.

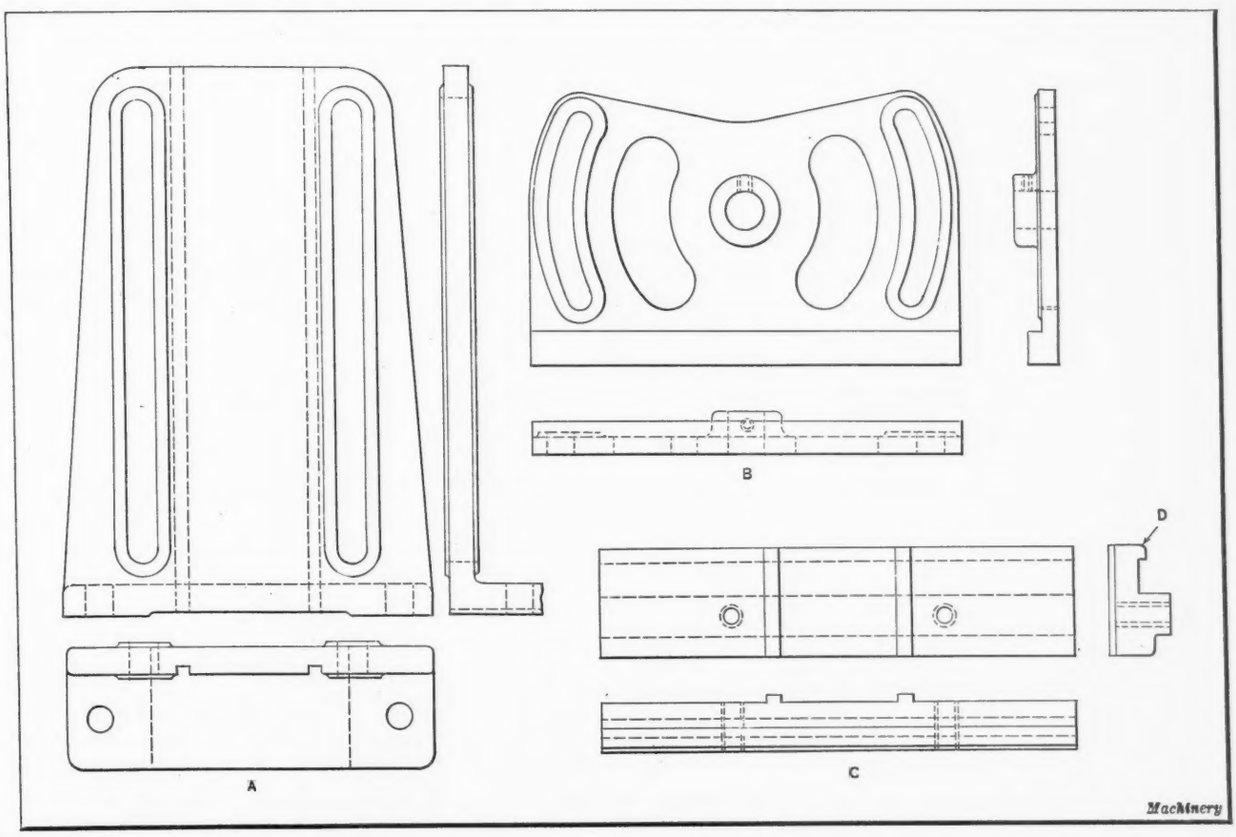


Fig. 17. Details of a Support for a Table which must be swiveled about a Horizontal Axis

Making Pressed-steel Bicycle Frame Parts

THE frame of a bicycle is made of seamless steel tubing joined at the corners by tubular "clusters" or special multiple elbows. Most of the pedal parts and the ball bearing retainers for the pedal shaft bearings are made of pressed steel. There are also many other members that are actually part of the frame—brazed to it—that are interesting examples of pressed-steel work. These include the seat-post cluster which connects the cross-bar and rear wheel upper fork; the crank hanger bracket which unites the frame at the lower "angle," furnishing the housing for the pedal-shaft bearing; and two similar corner pieces for connecting the steering-head section with the frame proper. The methods and special tools used in producing the seat-post cluster and the crank hanger bracket form the basis of this article.

Making Bicycle Seat-post Clusters

The design of the seat-post cluster is shown in Fig. 2. This part is made from No. 16 gage hot-rolled pickled sheet steel, 0.0625 inch thick, and is first blanked into the shape shown at *A* in Fig. 1 on a short-stroke Waterbury-Farrel power press. It is interesting to compare, at the outset, the evolution of the part from this irregular shaped blank to the completed cluster shown at *H*. After blanking, a No. 2½ Consolidated power press equipped with a double punch is employed to pierce two holes of special shape at the crotch and to slit the stock connecting these holes, as shown at *B*.

In the third operation, which is called the "breakdown," one punch is employed to form two circular bosses and at the same time offset the three sections that are later formed into the ends of the branches and finally brazed into the bicycle frame. The appearance of the work at this stage of manufacture is shown at *C*. This operation is performed on a No. 6 Consolidated press, using dies of simple design. The work is next delivered to the heat-treating department, where it is annealed by packing in pots in the regular way. The work is permitted to cool in the annealing pots.

The fourth press operation consists of forming all three branches to practically a U-shape and partially forming the stock to produce the seat-post hole. The work is done on the Bliss press illustrated in Fig. 3, which shows the dies used. The flat work is located on the lower die by two side blocks and a rear block. The upper die member has a former for the front branch and four others, resembling arms, for the other sections to be bent. Two of these are indicated at *A* in the illustration. For work of this kind, a cast-iron die-block is suitable, especially if the quantity of stampings to be formed is not large. This operation brings the part to the form shown at *D*. Before finish-forming the branches, two holes are punched in the previously drawn bosses. This operation is regularly performed on a No. 5 Consolidated press equipped with an overhead knock-out. Fig. 1 does not show a sample of the work after this simple operation.

The next two operations (the sixth and seventh in sequence) close the rear branches to an oval shape, as indicated at *E*, and partly close the main stamping as shown at *F*, both of these operations being performed on a No. 4 Consolidated power press. The eighth operation is sizing the upper end of the center hole *A*, Fig. 2, which after the seventh operation is left approximately oval in shape, as plainly shown at *F* in Fig. 1. After the eighth operation, the work looks like the sample shown at *G*. This operation is also performed on a No. 4 Consolidated press, using a plain cylindrical punch.

The last operation—the final closing of the cluster—is accomplished by means of the dies and arbors illustrated in Fig. 4. It will be seen that one shouldered arbor is used in hole *A*, Fig. 2, which fits the previously sized upper end, and that another arbor at 88 degrees with the first is inserted in hole *B* to obtain the size of this hole and establish the correct angularity of this end of the cluster with respect to the seat-post hole. With the work located in the die grooves by this means, a spreader block *A*, Fig. 4, hinged to the die, is employed to prevent the closing of the rear branches and establish the 19-degree angle. (See Fig. 2.) The die is so made that the spreader block can be replaced to accommodate clusters having rear branches that are to be closed to different angles. The spreader block is a wedge-shaped member and carries a small piece of rubber underneath it to act as a buffer and to strip the cluster from the die at the completion of the downward stroke of the press ram.

The upper die is of a simple design having grooves to match with those in the lower member, and

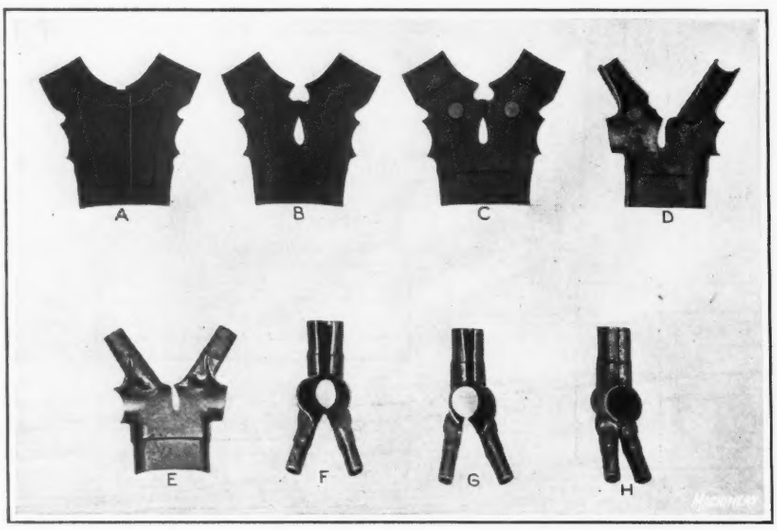


Fig. 1. Bicycle Seat-post Cluster in Various Stages of Completion

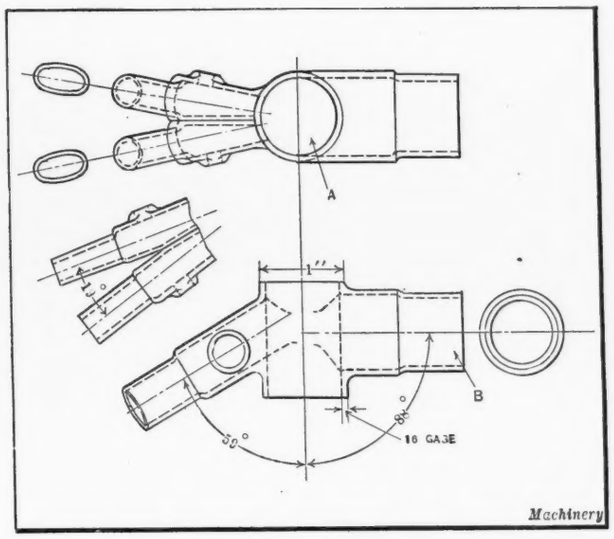


Fig. 2. Bicycle Seat-post Cluster

containing a clearance hole for one of the previously formed bosses. One additional operation is performed on the clusters after they have been taken from stock preparatory to shipment. This consists of sizing the front and rear branches to fit the particular tubing size specified by the customer. The finished cluster is shown at *H*, Fig. 1.

Making Crank Hanger Brackets

Bicycle crank hanger brackets of the type illustrated in Fig. 6 have the main part made from hot-rolled pickled steel, 0.095 inch thick. The brackets are drawn from a 5 19/32-inch blank into a cup in a number of operations. The bottom of this cup is finally punched out and the reinforcements *A*, *B* and *C* that fit the various sizes of tubing of which the bicycle frame is made, are assembled. After blanking, the shell is drawn to 3⅛ inches in diameter by 1⅞ inches deep (inside dimensions) on a Toledo toggle press. This shell, as well as the appearance of the work after each successive operation, is shown in Fig. 5, together with the reinforcements before and after being formed.

The shell is annealed to relieve the strains set up in the first drawing operation and oiled to preserve the dies in the subsequent operations. The first redrawing operation is performed on a Waterbury-Farrel 10-inch stroke press and produces a shell having a 2⅜-inch inside diameter and a 2 9/16-inch inside depth, as at *B*. The second redrawing operation is performed with the same type of equipment as the previous operation, the inside dimensions of the shell being 2 inches in diameter by 3⅛ inches deep. This shell is shown at *C*.

The irregular edge at the open end of the shell produced by drawing is then squared with a fly cutter, holding the work vertically on any convenient drilling machine. After squaring the open end, the bottom of the shell is punched out on a No. 54 Toledo straight-sided back-geared press. Two holes are next pierced midway between the ends of the shell, in which the two front reinforcements *A* and *B*, Fig. 6, are subsequently assembled. A similar punching operation is then performed for the two rear reinforcements *C*, which leaves the work as shown at *D*, Fig. 5. The punch and die used in punching the front reinforcement holes are illustrated at the left in Fig. 7.

The holes in the drawn shell are oval, as this shape is necessary to provide sufficient stock for drawing up the bosses, which is performed in a subsequent operation. The

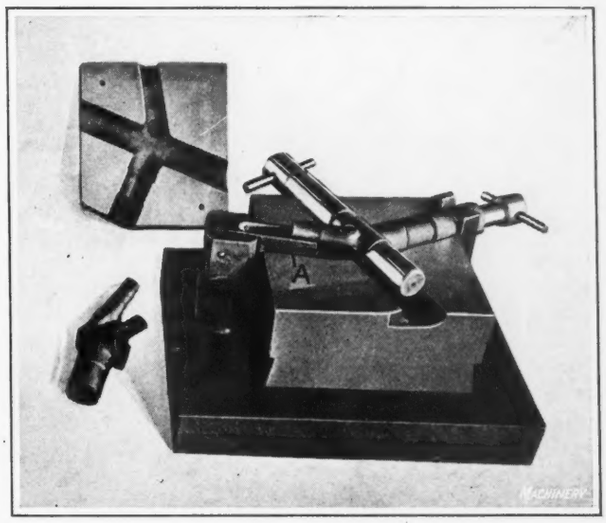


Fig. 4. Dies employed in the Final Closing of the Cluster

dies used consist essentially of slabbed arbors having steel bushings for the punches. The punch used for the front reinforcement holes is shown standing on the die plate. The shell is slipped over the arbor and stopped by a collar. After the first hole is punched, the shell is turned to locate it for the second hole, by a gooseneck lever *A* having an oval-shaped projection *B* which drops into the first hole punched when the lever is swung forward on its hinge.

In punching the holes for the rear reinforcements, another arbor is used in this die; the die has two die bushings so that both holes can be punched at one stroke of the press. Their lateral position is determined by a collar-stop on the arbor and their angular position relative to the front reinforcement holes by the use of a gooseneck lever, similar to the method of locating the second front reinforcement hole. The angularity of the rear reinforcements *C*, Fig. 6, with the front reinforcement *A* is 61½ degrees, and that between the two front reinforcements, 65 degrees.

Drawing the Bosses and Assembling the Reinforcements

After punching the holes, the shells are annealed, pickled, and oiled. They are then ready to have the bosses drawn for reinforcements *C*, Fig. 6. The arbors used in drawing the bosses are of the same general design as those used in punching out the

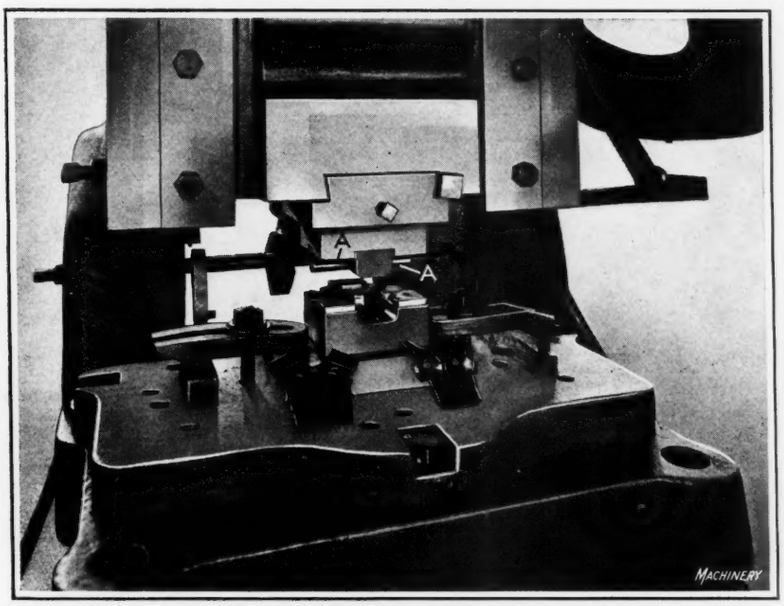


Fig. 3. Press with Dies used in the First Forming Operation on the Seat-post Cluster

holes around which they are drawn. These arbors are also shown in Fig. 7, at *C* and *D*, the former being used for the small reinforcement bosses and the latter for the larger ones. It will be noticed that the arbors have cylindrical bosses and that at the top of each there is an oval projection for locating the work. It will be understood that these arbors are held in a vertical post similar to the one that carries the arbors used in punching the holes. There is metal enough left around the oval holes in the work to draw over the cylindrical part of the arbor bosses and form the bosses on the hanger brackets. If these holes were punched round rather than oval, the amount of stock surrounding them would not be properly distributed to form a cylindrical boss; there would be too much material at some points and too little at others. If too much stock were left, that is, if the hole were punched round and to a smaller diameter than the major diameter of the oval hole, the stock would wrinkle at *E*, Fig. 6. Obviously, more stock is necessary at points *D* to draw the boss than is required at points *E*.

The bosses for reinforcements *C* are drawn first. The next operation in making the brackets is squaring both ends of the body to length, using a drilling machine as in the previous squaring operation, and a fly cutter. This operation is left until after the bosses for the reinforcements have been drawn, so that any irregularity in the

Fig. 5. Steps in the Making of a Bicycle Crank Hanger Bracket

ends of the work resulting from the boss-drawing operation can be corrected and a uniform over-all length established. After the ends are squared, the bosses for the front reinforcements *A* and *B*, Fig. 6, are drawn. The operations required in manufacturing the reinforcements are simply blanking out the work to the shape shown in Fig. 5, bending to a U-shape, and finally closing them over an arbor by using dies of simple design.

Before the reinforcements are assembled, the holes in the four bosses are beveled slightly with a fly cutter, this work being done on a drilling machine. This gives the piece the appearance shown at *F*, Fig. 5. In assembling the reinforcements, a Waterbury-Farrel 5-inch stroke press is used. The reinforcements are slipped into the upper member of the die, where they are engaged between their prongs. On the descent of the press ram the lower end is forced through the holes in the tubular main body and against an arbor within, on which the work rests, until the four ears *J* of the reinforcements are spread and bent at a 90-degree angle so as to clinch them on the inside of the bosses.

Both the front and rear reinforcements are assembled with the same style of equip-

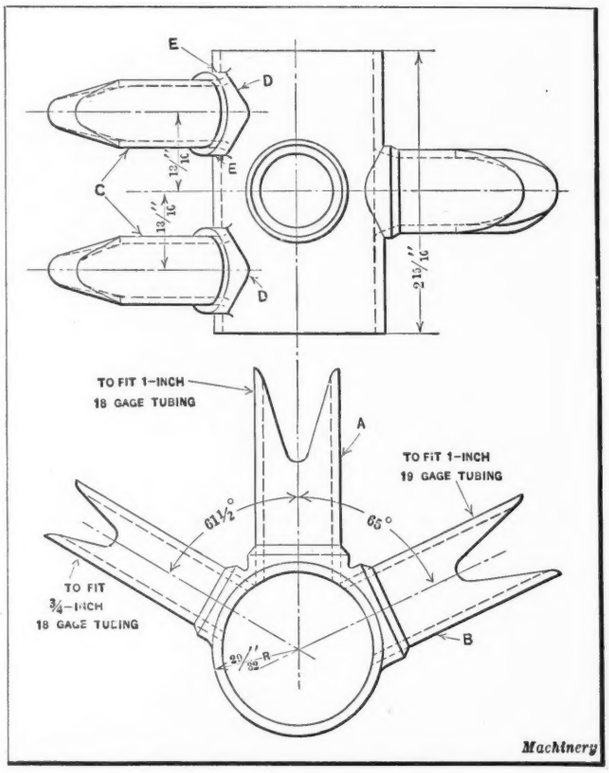


Fig. 6. Bicycle Crank Hanger Bracket

ment, the operation on the rear reinforcements being shown in the heading illustration. Finally, the assembled reinforcements are sized to fit the tubing to which they are to be brazed, for which purpose a simple die-block, a punch of suitable diameter, and a ring gage are used. The practice described in the foregoing is that followed by the New England Pressed Steel Co., of Natick, Mass.

* * *

An interesting piston-ring testing apparatus has been devised by the firm of Adolphe Saurer, Arbon, Switzerland, for testing the uniformity of the pressure along the circumference of cast-iron piston-rings. This device enables the pressure of the piston-ring to be read off on a dial. A master piston-ring is used as a guide for determining the correct pressure of the piston-rings to be tested. The apparatus is adjusted to this master piston-ring, but it can be used for different sizes of piston-rings by making the required adjustments. This apparatus is made in seven sizes for testing piston-rings from 2 to 6 inches in diameter, each apparatus having a capacity range of about ⅝ inch.

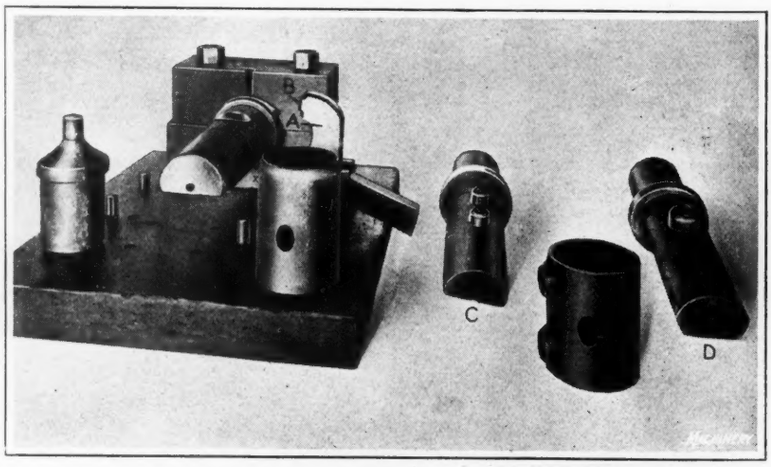


Fig. 7. Die for punching the Reinforcement Holes in Bicycle Crank Hanger Brackets, and Auxiliary Arbors for drawing up the Bosses

The British Metal-working Industries

From MACHINERY'S Special Correspondent

London, October 14

PRACTICALLY every branch of industry can now point to a slow but continuous improvement. This is all the more satisfactory in view of the somewhat pessimistic view that arose from the threatened trouble in the Near East. Although there is much hesitation in laying out capital for the development of schemes of any magnitude, confidence is undoubtedly returning, and taken in the aggregate, the leading branches of the engineering industry are receiving more orders, while manufacturing departments in most districts are engaged on somewhat larger outputs.

Conditions in the General Engineering Field

Although in the general engineering field many manufacturers are still only just able to keep their works running by selling products at practically cost price, the number of firms that are getting out of this rut is added to every week. Buyers are coming forward with more confidence and firms are steadily absorbing more men. Rolling stock makers and electrical engineering concerns continue to add to their list of orders. The activity among textile machine makers promises to continue, and the year's trading with this class of equipment for Japan, China, and India will represent a large total value.

The Machine Tool Industry

In the machine tool industry it is felt that business is definitely on the upward grade, although the movement is very slight and varies from week to week. Several prominent manufacturers are working at from 40 to 50 per cent capacity; one firm reports having sufficient orders on hand to insure working at the existing strength until practically the end of the year. Meanwhile, the prospect of obtaining additional orders is brighter. The heavy electrical trades and the railways, in particular, are said to be displaying a considerable amount of interest in the new machinery market. The latter, however, have not begun buying on a scale which the position demands, in spite of representations made by locomotive engineers to their directors.

Now that large stocks of finished machines have been depleted considerably, it is expected that the improvement in the trade will be directly reflected in increased activity in the shops. In the Manchester district the principal activity is on machines for India, Egypt, South America, South Africa, and Japan, where railway developments are the chief cause of the demand. American competition for this export trade is keen, and in several cases German manufacturers have made strenuous attempts to get a hold in these markets.

Machine tool makers have not been able wholly to convince customers that reduced costs have been anticipated and that no advantage could accrue from waiting. Prices today, however, are in some cases not more than 70 per cent above pre-war prices. Very little is heard now of machine tools being purchased from government war stock. Whether this is due to the fact that all salable stock has been disposed of, or to diplomacy on the part of the authorities, is not clear. Paris dealers are reported to continue to buy reconditioned British machine tools that had done duty on French munition work, and naturally this reacts unfavorably on British exports of machines to France. Makers of sheet-metal working tools in the Wakefield district report a healthier tone, and are finding their chief market in the home trade.

Exports and Imports of Machine Tools

Exports of machine tools in August showed a decided rise. The tonnage was 819, as compared with 536 for July, the values being £105,653 and £75,549, respectively. This is the first increase since last March when the tonnage reached over 1400. Imports also rose, the tonnage being 431 with a value of £56,604. The value per ton of exports fell from £140 to £129, but imports showed a rise from £121 to £131 per ton.

England is now exporting, in tonnage, about three-fourths the pre-war quantities, while imports are slightly above pre-war averages and there is a tendency to increase. Only in the classification "presses, punches and shearing machines" was the tonnage of machines exported less than those imported. All other classes of machine tools show a preponderance of export tonnage over import.

The Small Tool Field

In the small tool field makers have no hesitation in producing steadily for stock. This trade has never reached the stage of stagnation suffered by the machine tool industry, and the general improvement is already seen in the increasing number of orders which, though small, are sufficiently numerous to keep most makers busy. One firm in the Midlands has now more customers on its books than in normal times. In some districts the demand for jigs and fixtures is increasing, and tooling equipment designed particularly for use in connection with railway electrification has led to one or two firms receiving substantial orders.

The Automobile Industry

In the automobile industry, it is apparent that the end of the season has been reached, although many firms are still effecting fairly large outputs particularly those engaged in the light car field, and costs of production are falling rapidly. In the London district automobile manufacturers engaged on heavy commercial vehicles are busy and are finding an improved demand from overseas. Australia is especially mentioned. The inquiries from Brazil and the Argentine for road vehicles are also considered promising. In both those countries ambitious road extension and improvement schemes are in hand, and there will soon be an increased demand for automobiles. The Ford Motor Co. has acquired a valuable water site frontage at Millbrook, Southampton, for the erection of a factory, which is expected to give employment to 2000 men.

Iron and Steel

The relighting of furnaces in several districts is proof of a welcome awakening of activity in the iron and steel trades. There have been heavy shipments of pig iron to America, which has caused something of a scarcity at home, and in some cases quite heavy stocks, accumulated during the slump, have been practically disposed of. Shipments to the United States, however, are now diminishing. This activity has done good by causing the collieries to place orders for equipment. Competition for steel orders is keen.

Sales of finished iron and steel have been checked in the eastern markets, but this result of the political trouble has not spread to the home market or elsewhere. Continental makers still have to maintain their prices at too high a figure to obtain much business in this country. The total exports of iron and steel in August were 269,983 tons valued at £5,052,852, corresponding to £4,656,582 in July.

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STANDARDIZING BEARING BUSHINGS

Several years ago, one of the largest manufacturers of bearing metals and bushings for bearings undertook to standardize the extensive line of bushings used in machine construction. On examining the sizes ordered, he found that they comprised about 7500 bushings covering the usual range of sizes, but all differing in some one dimension. By careful study he reduced, with slight modifications, the number of bushings to 180, and notified his customers that those sizes would be considered standard and carried in stock, insuring purchasers prompt deliveries and a reduction in cost of about 50 per cent as compared with bearing bushings made to order.

This standardization work was completed several years ago, but although its advantages are obvious, the manufacturer has found it very difficult to induce his customers to change their bearings in some unimportant dimension so that his standard bushings may be used. There is no good reason why most new machines should not be provided with a standardized line of bearing bushings, and the adoption of stock sizes would decrease their manufacturing cost considerably.

The same advantages apply to the use of standard sizes of bearing bushings as to the use of standard threads and even standard gears. One of the large gear manufacturers carries a line of standard gears in stock so that customers may obtain from dealers located in all the large manufacturing centers, gears of given diameters and pitch, without the delay and expense of having them made to order. The adoption of standard bearing bushings should be a much simpler proposition, because not nearly so large a variety is required as in gears, where there are so many different combinations of diameters, pitches, and numbers of teeth.

* * *

EQUIPMENT OF TRADE SCHOOLS

The young man who receives his shop training in a trade school should be given an opportunity to become acquainted with as wide a range as possible of the standard machine tools. A great many trade and engineering school shops fail in this respect. They order a large number of lathes, all of the same make and size, while other types of machine tools, as a rule, receive but scant attention. A better all-around training would be provided for the boys if the shop had a greater representation of the different types and makes of machine tools. Take the grinding machine, for example. In the machine shop of a large, middle-western university there is an ample supply of lathes and shapers, but only one grinding machine. Yet the grinding machine is now so important a part of shop equipment that unless it is given a prominent place in the school shop, students who go into practical work will have an erroneous idea of the relative importance of this machine. Even such machines as disk grinders should be installed in any well-equipped trade and engineering school. The disk grinder is an economical machine for a great number of operations, and students should become acquainted with its use and application.

The equipment in trade schools need not be heavy. The smaller sizes of the general types of machine tools are more satisfactory than the larger, but variety is required, and at least one machine of each of the more generally used types should be installed. Those in charge of trade and engineering school machine shops should realize that the most important thing is not that the boys acquire manual dexterity in the handling of tools, but an all-around knowledge and understanding of the uses and application of modern machine tools in actual production. If the trade school is to survive, it must provide a training similar to that of an apprenticeship system, and must give the engineering student a broad-gage idea of modern production methods rather than mere manual training.

* * *

TAKE CARE OF YOUR MACHINE TOOLS

Almost every manufacturer realizes the need of up-to-date machine tool equipment if the greatest possible production is to be attained; but many do not realize the importance of keeping their machine equipment in the best possible condition. Nothing so lowers the efficiency of the working force of a plant as rundown equipment. The operator of a machine that is in need of alignment or repair usually lacks the interest in his work that an operator has who is running a machine in first-class condition, and this results in a reduction in the efficiency of both the man and the machine.

During the war period when machines had to be used for two or three shifts, there was no opportunity to keep the equipment in good condition; but with normal use there should be no difficulty in so planning the work that machine tools can be regularly inspected and overhauled. With such attention, more and better work can be produced, the operators will take greater interest in their work, the machines will last longer and money spent in taking care of them will save some that otherwise would have to be spent for new machines.

Every manager of a machine shop, whether it is large or small, should make it his business to see that the entire equipment of his shop is regularly inspected for defects or breakages, and especially that all needed repairs are made as promptly as possible.

* * *

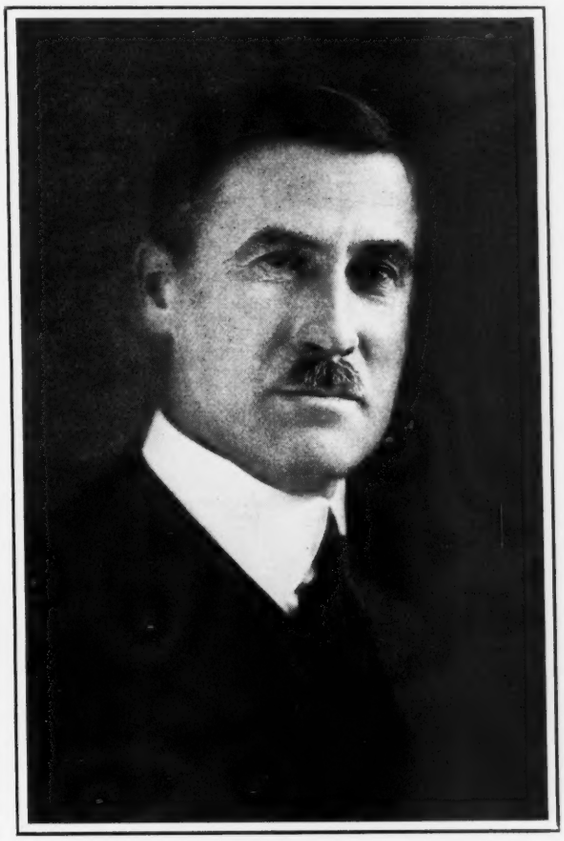
THE COST OF CHANGING LABOR

As industrial activity increases, the machine shops of the country will be confronted by the problem of training a new labor force. One of the troubles that follow trade depressions is that the old workers do not always return to their old jobs and in many cases the valuable experience of former employes is lost. Numbers of the new men are unfamiliar with the work and require a considerable period of training before they can produce as well and as cheaply as their predecessors did. The cost of training a new working force, or even a part of the force, in the machinery industries will run into large figures and must be reflected in higher prices for the product of the shops. This cannot be avoided, and is mentioned merely as one of the contributing causes to the higher prices for machine tools now being put into effect by many of the builders of machine shop equipment. Other causes are the increased prices for materials, and the high overhead per machine built, due to the comparatively small volume of business being handled at the present time.

National Machine Tool Builders' Convention

THE twenty-first annual convention of the National Machine Tool Builders' Association, held in Lenox Mass., October 3 to 5, was marked by a large attendance of the membership. A great many questions of importance in the machine tool industry were discussed. The topic of standardization was dealt with, and the association, working through special committees, will shortly take up important work in this direction, the first subjects to be considered being T-slots; tapers for lathes; drilling machines, grinding machines and milling machines; and spindle noses. The committee appointed by the association to cooperate with the Department of Commerce held its first meeting, and the second meeting of this committee will be held shortly in Washington. The subject of patents was ably dealt with by Joseph K. Schofield, chief of patent department, Niles-Bement-Pond Co., in a paper entitled "What Patents are Worth to the Machine Tool Industry."

Selling problems were dealt with in papers read by W. A. Viall, secretary, Brown & Sharpe Mfg. Co., Providence, R. I.; O. B. Iles, president, International Machine Tool Co., Indianapolis, Ind.; Frank N. MacLeod, president, Abrasive Machine Tool Co., East Providence, R. I.; and Paul E. Thomas, Kempsmith Mfg. Co., Milwaukee, Wis. The general manager of the association, Ernest F. DuBrul, presented a report for the year, which indicated a great deal of activity and substantial progress during the last twelve months.



E. J. Kearney, Newly Elected President of the National Machine Tool Builders' Association

The President's Address

The address by the president of the association, August H. Tuechter, of the Cincinnati Bickford Tool Co., contained a great many ideas of unusual value not only to the machine tool industry, but to all branches of the machine-building industry.

Mr. Tuechter first reviewed the work of the National Machine Tool Builders' Association, which has just completed its twentieth year. He mentioned the problems that the industry has had to solve, and those yet to be solved, pointing out the lines along which a trade association should develop to be of the greatest value in producing industrial stability, thereby promoting the best interests not only of its members, but also of the country at large. The constructive influence of the association was dealt with, and its progress reviewed. The necessity for improved cost systems was another topic that was covered.

Cost of Unavoidable Idleness in Machine Tool Industry

On the problem of the cost of periodical unavoidable idleness in the machine industry, Mr. Tuechter spoke as follows:

"We are apt to think that the excess capacity in our industry, which has loomed so large and so idle during the last two years, is wholly a result of the war activity, but this is only partly true. The machine tool industry has always needed a maximum capacity considerably in excess of its average demand, taken over a period of years. This is because our industry naturally suffers from what electrical engineers term a "bad load factor" in electric light plants, where a high peak load makes a large plant necessary, though the average load is low. The electrical people have given this load factor serious attention, and the peak load consumers pay rates in proportion to the expense of carrying idle equipment.

"It appears to me that we could well give the same kind of consideration to the financial effect of our load factor. False bases for costs make false bases for prices. Too many in our industry use the method of dividing the total amount of expense incurred for a given period by the productive hours for that period, and calling the quotient their burden. This has been truly described as a method of wasting money to give clerks exercises in long division to conceal costs.

"Basing prices on such figures in boom times simply blinds one's eyes to the necessary cost of idleness in this industry, and leaves that cost out of the price of the product. It prevents the accumulation of a necessary reserve to carry over the succeeding depression. It gives a false impression of profits during the peak-load period. It encourages unfair competition in times of depression, and makes for the cutting of prices below those of competitors who believe that honestly made goods are worth a fair price carrying a reasonable profit, and should not be sold below cost. It also keeps the whole morale of the industry low; it destroys our self respect; it prevents us from paying our employes what other industries will pay the same men; it makes our industry unattractive to the kind of men we ought to draw into it as engineers and salesmen; and it pays the industry's investors a smaller dividend than they can get on stocks bought in the open market, whose earnings are not so fluctuating and whose stockholders do not run the same risks as ours.

"Let us openly tell the world about the demand fluctuations this industry encounters and why its bad load factor necessarily increases the burden rate to a figure much higher than one in a more stable industry. Let us study these things ourselves and see that our customers recognize these costs as necessary parts of price, and we shall have no difficulty in getting fair prices for our product. Unless we, ourselves, study these things, our customers will not be convinced that the facts really exist. The man who is ignorant of his true costs never has a firm basis for his price policy and can never command the respect, either of his competitors or of his customers. In the cycle we

are now entering, our members should revise their cost systems so as to prevent the errors of the past."

Exposing and Eliminating Trade Abuses

"A very constructive work of a trade association," said Mr. Tuechter, "is the exposure and elimination of abuses, and the study of causes and effects of mistakes in policy. Some buyers have put excessive pressure on machine tool builders, because such buyers have a very different situation as to demand than our industry has. It is good work to make plain to all the world that we must operate our business according to the nature of its demand. Ours is a secondary demand that increases and decreases with demand for the products of our customers and is affected only slightly, if at all, by the price of our product. We all know that when our customers' shops are largely idle, no price above a free gift will induce them to buy tools that they have no reasonable prospect of using. We cannot stimulate our market when direct costs of building machines are lowest—that is, during years of depression. Our customers buy when active business requires more production, and when the buyer feels sure that a profit will inure to him out of the larger product of our machines. If and when a user cannot figure such a profit, his ears are shut tight to the song of the machine tool salesman.

"We could never gouge our customers if we tried, because they could all make machine tools in their own shops, if our prices were so high that the cost and trouble would be less in making their own machines. The seller of machine tools can never break through these natural limits to price that protect the buyer.

"Economic law protects our customers, but it heavily penalizes our own deficiencies. Due to all these things, very great profits have not been reaped by machine tool builders, as compared to other industries, and perhaps never can be. But at least we should learn to avoid some mistakes that have reduced or even wiped out the naturally small returns that we could earn. It is constructive work to make these things clear to potential competitors so that they will not rush into this industry in ignorance and make a naturally bad situation worse.

"It is constructive work to stamp out all abuses. Taking advantage of the naturally weak position of the machine tool industry, some unscrupulous buyers have not hesitated to use falsehood and threats of loss of business to browbeat some of our members. It is constructive work to gather information as to the use of such methods to warn our members against their effects, and to point out the better way."

New Officers of the Association

The following officers were elected for the coming year: President, E. J. Kearney, Kearney & Trecker Corporation, Milwaukee, Wis.; first vice-president, Winslow Blanchard Blanchard Machine Co., Cambridge, Mass.; second vice-president, O. B. Iles, International Machine Tool Co., Indianapolis, Ind.; treasurer J. N. Heald, Heald Machine Co., Worcester, Mass. The board of directors consists of the officers and August H. Tuechter, Cincinnati Bickford Tool Co., Cincinnati; E. P. Welles, Charles H. Besly & Co., Chicago, Ill.; Frank N. MacLeod, Abrasive Machine Tool Co., East Providence, R. I.; C. Wood Walter, Cincinnati Milling Machine Co., Cincinnati, Ohio; and H. W. Dunbar, Norton Co., Worcester, Mass. Ernest F. DuBrul was re-elected secretary and general manager.

E. J. Kearney, the newly elected president, is one of the most successful machine tool manufacturers in the country. He was born on a farm in the state of Iowa, in 1868; graduated from the Iowa State College, B. M. E., in 1893; entered the machine tool business via the drafting-room, under the instruction of the late Frank Kempsmith, in 1894; and formed a partnership with Theodore Trecker, to manufacture milling machines in 1898.

MEETING OF THE STEEL TREATING AND DROP-FORGING SOCIETIES

The annual meeting of the American Society for Steel Treating held in Detroit, October 2 to 6, was attended by a large proportion of the membership, and the exposition of equipment for heat-treating, hardness testing, forging, and diemaking, held in conjunction with the convention, attracted a great deal of attention. The exhibits covered a complete range of temperature-controlling apparatus, furnaces, and other hardening room equipment, as well as forging machinery. A number of machine tools, especially those suitable for making drop-forging dies, were also exhibited. The American Drop-Forging Institute held its annual meeting simultaneously with the Steel Treating Society, and this brought together a large number of men engaged in work in which the heat-treatment of steel is of particular importance.

Among the papers read, the following may be mentioned: "Carburizing and Decarburizing in Casehardening," by H. B. Knowlton; "Casehardening," by A. H. d'Arcambal; "Irregularities in Casehardened Work Caused by Improperly Made Steel," by E. W. Ehn; "Some Features of Industrial Heat-treating Electrically," by C. L. Ipsen; "Heat-treating in Lead," by R. B. Schenck; "Furnace Atmospheres and Their Relation to Formation of Scale," by G. C. McCormick; "Thermal Transformation of Some Chrome-Vanadium Steels," by J. S. Vanick; "Heat-treating of Automobile Springs," by A. E. Fuller; "The Uses and Abuses of Tool Steels from the Standpoint of the Producer and Consumer," by W. P. Woodside; "Effects of Structure upon Machining of Tool Steel," by J. V. Emmons; "A Metallographic Study of Hollow Drill Steel," by N. B. Hoffman; "Lathe Breakdown Tests of Some Modern High-speed Tool Steels," by H. J. French and Jerome Strauss; and "Heat-treatment and Properties of Duralumin," by H. C. Kneer.

* * *

DETERMINING THE DIAMETER AT THE END OF A TAPERED ROD

By C. N. PICKWORTH

A simpler solution to the problem of determining the diameter at the end of a tapered rod than that presented on page 910 of July MACHINERY is given in the following. Referring to the accompanying diagram, angle a and radius

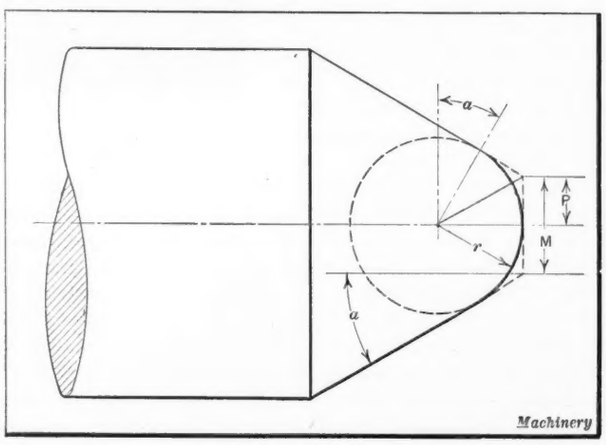


Diagram for finding Diameter at End of Tapered Rod

r are given. It is desired to find diameter M at the end of the tapered rod before the end is rounded to radius r. From the diagram it is evident that

$$P = r\left(\tan\frac{90-a}{2}\right) \quad \text{Hence,} \quad M = 2r\left(\tan\frac{90-a}{2}\right)$$

American Gear Manufacturers' Convention

THE same close attention to standardization problems that has characterized the meetings of the American Gear Manufacturers' Association in the past, was the main feature of the semi-annual convention held in Chicago October 9 to 11. Nearly all of the ninety-five member companies were represented by one or more delegates. Three new companies were elected to membership: The American Gear Co., 549 E. Illinois St., Chicago, Ill., with J. A. Bedford executive member; Dalton & Balch, Inc., 2333 Michigan Blvd., Chicago, Ill., with M. E. Dalton executive member; and Manns Mfg. Co., 454 Golden Gate Ave., San Francisco, Cal., with R. Manns executive member. The office of the secretary of the association, T. W. Owen, it was announced, is now located at Room 107, 2443 Prospect Ave., Cleveland, Ohio.

Papers Read Before the Meeting

After the welcome extended to the visiting members by William Ganschow, president of the William Ganschow Co., the business of the convention was devoted entirely to the reading of papers and to committee reports, mainly on gear standardization. George L. Markland, Jr., president, Philadelphia Gear Works, read a paper on "The Evolution of the Gear," a historical review of the use of gearing in early days. P. C. Molter, superintendent of the department of industrial education, National Metal Trades Association, spoke on "Apprenticeships." L. G. Hewins, sales manager, Van Dorn & Dutton Co., pointed out the advantages of buying castings at a set price per piece, rather than on a pound basis, because when the foundry—as well as the forge shop, in the case of forgings—works by the piece instead of by weight, there is an incentive to work close to the finished size, thereby saving metal as well as time in machining.

Two addresses relating to investigations of gear noises were made, one by Professor A. E. White, director of the department of engineering research, University of Michigan, and one by Professor Daniel L. Rich, of the same university. Professor White's paper treated of engineering research in general, with special application to gear noises; Professor Rich spoke specifically on "Standardization of Gear Sounds." A method by which gear noises might be investigated in a scientific way was outlined, and a committee appointed to go further into this problem.

Reports by Standardization Committees

Nearly all of the standard committees on standardization presented progress reports. The Bevel and Spiral Bevel Gear Committee presented the Gleason system—as outlined in a paper before the last annual meeting of the association, published in June, 1922, MACHINERY—for adoption as "recommended practice," for generated bevel gears, and it was so accepted by the association. A table of formulas on spiral bevel gear axial thrust was also accepted as recommended practice. A copy of this table may be obtained from the Gleason Works, Rochester, N. Y. An amplification of the Gleason system was also presented. This is published on page 228 of the present number. It will be submitted to the members of the association after publication and presented for adoption at a coming meeting.

The report of the inspection committee was adopted as recommended practice. This report covers methods, rather than specific tolerances, and deals with the testing of the involute curve, angular velocity, threads when part of gear combinations, worms, and hobs. The practice adopted is as follows:

Involute Curves

In order to determine the accuracy of the involute curve, it is necessary to have some instrument that will check this curve in the same manner as it is unwound from a base cylinder. An instrument of this type should have a straightedge rolling on the base circle of the gear and an indicator fastened to the straightedge, the indicator point being in contact with the gear tooth to be tested. As the straightedge is moved along, it will roll on the base circle, and the indicator which is in contact with the gear tooth should register zero if the involute curve is correct. If it is not correct, it will show the amount of inaccuracy. It is necessary that a gear should have the correct involute curve in order to function properly, and the involute curve-testing instrument can determine whether a gear has been cut off center, and whether the pressure angle of the gear is correct.

Angular Velocity

If a pair of gears are properly mated, they should function with uniform angular velocity, but in order to determine this, it is necessary to have some instrument which will test it. The principle embodied in an instrument of this type should be to test a known motion, such as produced by a pair of rolls, against the unknown motion produced by the mating gears, and the variation of the gears should be automatically recorded on a paper chart. If the involute curves are correct and the spacing is correct, the gears should run with uniform angular velocity; but if the involute curve is not correct, these instruments would show a variation in motion, and if the spacing of the teeth is not uniform, there will also be a variation in the motion.

Thread Inspection

"Go" and "Not Go" plug and ring gages of proved dimensions, the three-wire method for pitch diameter, or the projection method for pitch diameter, outside diameter, lead, angle, and form should be used. All plug gages and taps should be tested by the projection method.

If external threads are shown to be of proper diameter by the three-wire measurement, and at the same time are a good fit in a ring gage, they may be considered correct in lead, profile, and pitch diameter. On threads coarser than twelve per inch, good results can be obtained by the use of Prussian blue to prove up the bearing of the thread in the ring gage; if it is a good hand fit and shows good bearing surface, the lead, angle, and diameter are correct.

Internal threads that are tapped may be inspected by the "Go" and "Not Go" plug gage, but the tap should first be inspected by the projection method to insure correct lead, profile, and diameter. After an internal thread is smooth enough to show a good Prussian blue spotting off the plug gage, a half-section can be cut away and the plug rolled into the remaining half-section to show if the lead and angle are correct.

Worm Inspection

The lead of a worm should be tested by attaching the worm to the end of a master screw having the same lead as the worm to be tested and rotating the screw so as to feed the worm past a fixed indicator, bearing against the profile of the thread. The pressure angle of worms having rack type threads should be tested by inclining the worm from a vertical line the exact amount of the pressure angle, and sliding an indicator on a horizontal line with its working point on the profile of the tooth.

Worms having curved thread profiles should be tested for tooth form by running them, at right angles, with a master worm-wheel, and noting the bearing by the use of Prussian blue or some similar agent. On single jobs or small quantities, it should only be necessary to have the worm bear properly with its mating gear, unless special accuracy is specified.

Hob Inspection

"Go" and "Not Go" plug gages are to be recommended for testing holes. "Go" and "Not Go" plug gages with a key inserted are to be recommended for testing keyways, as the size of the keyway and alignment—in relation to the hole—can best be tested by this means. The concentricity of hubs, teeth and squareness of end of hub, can best be tested by the use of ordinary bench centers and a dial indicator.

Whether a gash is radial or not, can best be tested on bench centers, with a plug which carries a finger that can be inserted into the gash of the hob, and a sight reading taken. On straight-gashed hobs, it is necessary to test the parallelism of the gash with the axis of the hob; this can be readily done by mounting the hob on bench centers and passing an indicator along the gash. On spiral-gashed hobs, it is necessary to determine whether the spiral of the gash is correct or not; this can be tested either by the use of a form that has the correct spiral, or a special machine made with a taper attachment that will impart the necessary spiral rotation.

Ordinary gear tooth calipers are best adapted for measuring the thickness of all types of hob teeth. Where topping hobs, or worm hobs, are to be measured, the ordinary depth micrometer is recommended for measuring the depth of the tooth.

To measure correctly the contour of hob teeth, an instrument for this purpose is to be recommended. The hob should be mounted on a mandrel and a contact finger connected with an indicator should be passed along the contour of the hob. Any variations in the contour will be shown on the indicator dial. Charts can be made of the theoretically exact contour desired, and the hob teeth can then be checked against these charts.

The hob should be tested for lead, that is, to see whether all the cutting edges fall in a true helical path. A simple instrument is to be recommended in which a master screw with the same lead as a hob is used. The hob is mounted on the arbor end of this screw, and as both are rotated at the same time, an indicator can be used to detect the variation in the cutting edges. In this test, it is desirable to plot charts and keep records of the actual condition of the hob.

History of Gearing

In his paper on the "Evolution of the Gear," Mr. Markland pointed out that the earliest toothed wheel on record dates back to 300 B.C.; this was evidently a metal pinion engaging a metal rack, and was the operating mechanism in a water clock used in Egypt. Reference to this timepiece is made by Thomas Humpage in the Minutes of the meeting of the Institution of Mechanical Engineers held at Bristol, England, in July, 1908. Reference is also made by Mr. Humpage to a gear-cutting mechanism for cutting clock wheels, which appears to have been built about 1750; clock wheels were being cut on this device as late as 1908. The process of evolution seems to have made the greatest strides in clock gearing.

The epicycloidal teeth—at least shapes that may be termed epicycloidal—were the first in evidence. It appears that Leonardo da Vinci (1452-1519) took up the subject of the gear tooth. In an English book, published in 1702 written by Mandey, there is an essay on epicycloids and their use in mechanics.

Camus, a French engineer, who was born in 1699 and died in 1768, wrote an article on the teeth of gears about 1738. A translation was published in 1868. Camus goes into the epicycloidal form, but the translator, John Isaac Hawkins, while admitting that he was at first quite willing to agree that the epicycloidal was the only tooth form, states in an appendix that he has come to the conclusion that the involute curve will supersede it.

Engineering Research Work

In his address on "Engineering Research," Professor White pointed out the necessity for manufacturers to undertake more research work, because the ordinary engineering and technical society is not in a financial position to undertake work of this kind, although most of the leading societies would like to encourage such work if they were financially able to do so. It was pointed out that many universities are in a position to cooperate with either individual manufacturers or associations of manufacturers in carrying out research work. **Gear noise** is the particular problem of the gear manufacturer that requires more scientific analysis, to enable a determination of the causes that are most active in producing noise, and the influence of various modifications in design on the elimination of gear transmission noises.

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INCREASED PRODUCTION FROM IMPROVED TOOLS

By HARRY E. HARRIS

The writer read with interest the article "Increased Production from Improved Tools" on page 132 of October MACHINERY. While the improvement is marked in the designs shown in Figs. 3 and 4, the writer believes that the improvement would be even greater if pivot pins *C*, Fig. 4, as shown in the article referred to were relocated at the intersection of the center lines through the two drill bushings. Thus when the body of the jig was swung from one drilling position to the other there would be no necessity for moving the base of the jig on the drill table. With the design shown it is necessary to move the jig from side to side a considerable amount and realign it with the drill each time a hole is to be drilled. This causes an unnecessary loss of time. By widening the base and lengthening the rocking member of the jig the pivoa pins *C* could be readily located as suggested.

* * *

SCULPTURING BY MACHINERY

A method of reproducing works of sculpture, as well as making works of sculpture from living models, that appears to introduce a new epoch in this art, has been invented by a Chicago engineer, W. F. Engelmann, 832 E. 51st St., of that city. Mr. Engelmann has published a booklet entitled "A New Sculpturing Method" in which he explains, how, by means of optical devices and machinery, he is able to do away almost entirely with the time consumed by the model "sitting" for the sculpture, as the presence of the model is required for a few minutes only. It is claimed that on account of the optical and mechanical means used an absolute likeness of the model is easily obtainable, and that reproductions can be made in any material and in any size from the largest in marble or bronze for monuments, to the smallest in gold for jewelry. It is further claimed that any person with very little training is able to make the most accurate reproductions, and that the time required is reduced to hours instead of days or months. The machines used for this method of sculpturing have been patented, and the pamphlet referred to contains a complete mechanical description of the mechanisms of the machines used.

MACHINING MOTOR TRUCK REAR AXLES

By HAROLD F. BLANCHARD

The machining operations on the rear axle of the Model AB Mack truck manufactured by the International Motor Co., New York City, are of particular interest because of the size of the piece and the accuracy required. It is believed that the drop-forging from which this axle is made is the largest used in the automotive industry. The forging weighs 350 pounds, is more than 5 feet in length and is made of chrome-nickel steel. It is delivered to the factory as a solid forging, and it is obviously quite a job to bore the large yoke opening at the center. This requires a machine of great size, having a large swing. The problem is also greatly complicated by the close limits of accuracy called for. The yoke is required to be faced within 0.004 inch and counterbored to within 0.003 inch of the exact size.

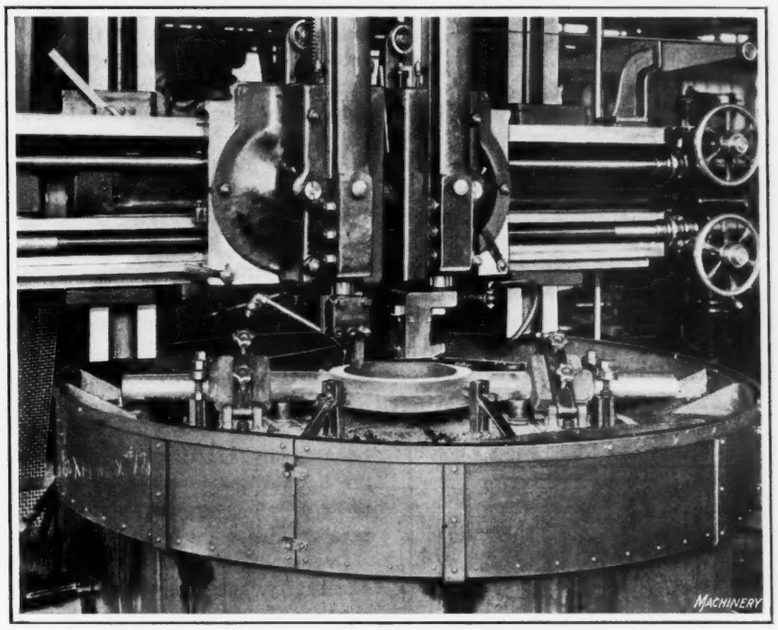


Fig. 1. Boring and facing Motor Truck Rear Axle

The machine used for performing the boring and facing operations on the axle is a Bullard "Max-i-Mill," specially equipped for this job. A general view of the machine with the forging secured to the fixture is shown in Fig. 1. In this illustration the tool in the left-hand holder is shown just starting the final counterboring cut. The holder at the right contains the facing cutters, which are so controlled that the two faces are cut simultaneously. In the illustration Fig. 4 is shown a close-up view of the facing cutters operating simultaneously with the rough-boring cutter.

Another interesting operation on the forging is boring the holes in the long projecting bars that form the axle tubes. These holes must be bored out of solid metal, for which purpose a gun drill is used. The gun drill is provided with means of feeding lubricant to the point of the tool. The total length of the two holes is about 4 feet, and they are required to be aligned with sufficient accuracy to permit a drift bar with only 1/32 inch clearance to pass freely through the entire axle. This boring operation is accomplished on a large engine lathe equipped as shown in Fig. 2.

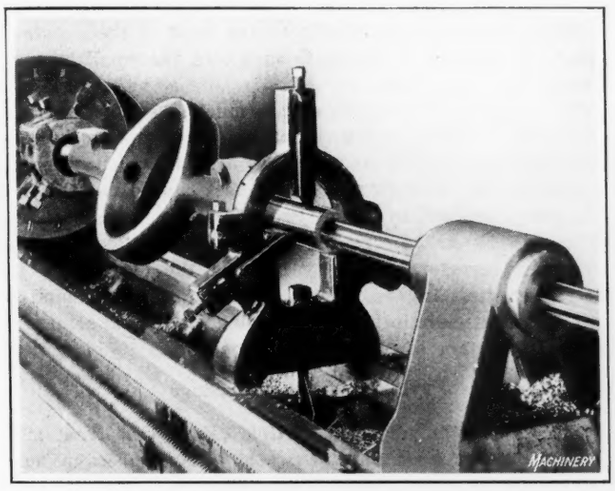


Fig. 2. Boring Axle Spindle with Gun Drill

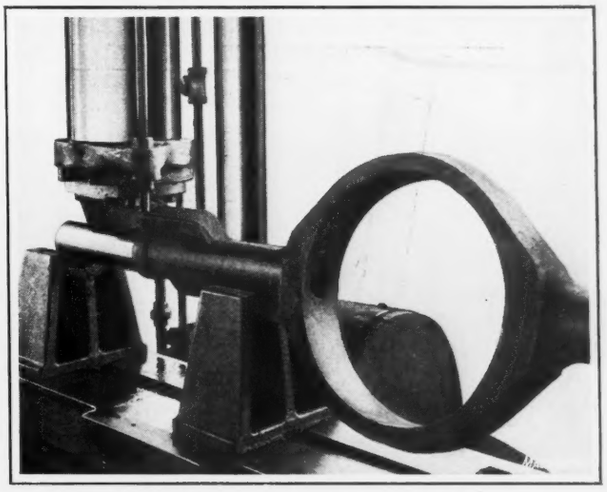


Fig. 3. Straightening Axle Forging after Heat-treatment

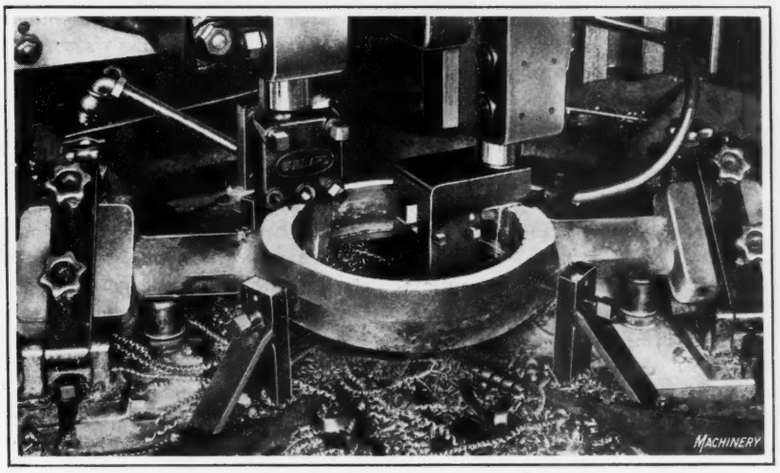


Fig. 4. Close-up View showing Boring and Facing Tools operating simultaneously

The axle is heat-treated between the roughing and finishing operations, being quenched while suspended vertically in order to minimize warpage. However, the nature of the material is such that a certain amount of warpage is unavoidable. This necessitates straightening

the axle after it has cooled. The forging resists bending to such an extent that it is necessary to use a 350-ton hydraulic press for the straightening operation. An axle in position on the straightening blocks is shown in Fig. 3.

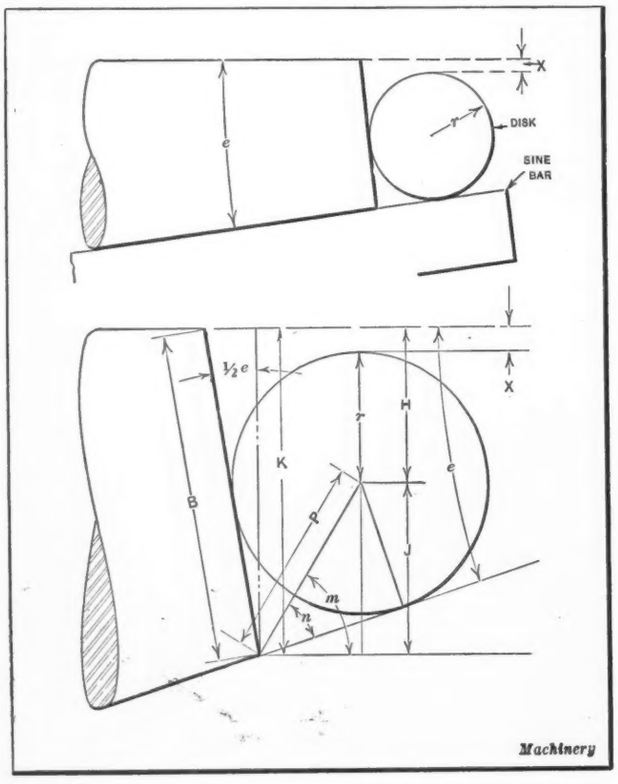
The spindles or turned ends of the axle are of rather large diameter and are exceedingly awkward pieces to turn. For this work, large and rigid bell extensions are mounted on the faceplate, and steadyrests are employed to enable the spindles to be kept within the limit of 0.0005 inch.

* * *

MEASURING DIAMETER AT SMALL END OF TAPER PLUG GAGE

By W. G. HOLMES

The method here described for determining the diameter at the small end of a taper plug gage has been found very satisfactory. The procedure is as follows: The plug is mounted on a sine bar so that the top edge of the gage is parallel with the surface plate. A disk is placed in the corner formed by the end of the plug gage and the sine bar, as shown in the upper view of the illustration. The end of



Method of measuring Diameter at Small End of Taper Plug Gage

the plug gage must, of course, be ground to a true flat surface and at right angles to its center line. A reading is taken over the plug gage and over the top of the disk by means of a height gage, the difference between these two readings giving the dimension X.

The known dimensions then are:

e = angle of taper;
r = radius of disk; and
X = difference between readings over plug gage and over disk.

From the dimensions given it is required to find the diameter B at the small end of the plug gage. Now, we have,

$$H = r + X;\ n = (90 - \tfrac{1}{2}\ e) \div 2$$
$$m = n + e;\ P = r \text{ cosec } n$$
$$J = P \sin m;\text{ and } K = H + J$$

Then

$$B = K \sec \tfrac{1}{2}\ e = (H + J) \sec \tfrac{1}{2}\ e$$
$$B = (r + X + P \sin m) \sec \tfrac{1}{2}\ e$$
$$B = (r + X + r \text{ cosec } n \times \sin m) \sec \tfrac{1}{2}\ e$$

FLEXIBLE COUPLINGS AND THEIR USE

Flexible couplings are the most common mechanical means of compensating for unavoidable errors in alignment of shafts and shafting. When correctly applied, they are highly efficient. For joining lengths of shafting without causing loss of power from bearing friction due to misalignment, and for use in direct motor drives for all kinds of machinery, the value of the flexible coupling is now generally recognized. The fact that lineshafting will sag if of considerable length, makes the use of a flexible connection essential. Flexible couplings are not intended to be used for connecting a driven shaft and a driving shaft that are purposely placed in different planes or at an angle, but simply to overcome slight unavoidable errors in alignment that develop in service.

For direct-driven machinery, where the motor and machine are installed on a concrete foundation, the machine bearings should first be carefully lined up with the armature shaft of the motor. The misalignment that is bound to develop afterward, as the grouting around the machine allows it to settle, may be guarded against by connecting the two shafts with a flexible coupling designed to take care of these small but serious errors in alignment. In hanging lineshafting, it is practically impossible to align the hanger bearings perfectly, but, as in the case of setting up a direct-connected motor-driven machine, the greatest care should be taken to keep the error as slight as possible.

Ordinarily, a flexible coupling will not transmit power efficiently where the offset is more than 1/16 inch or where the angularity is greater than 5 degrees. If the shafts are out of alignment more than these amounts, it is preferable to use universal joints or couplings of the Oldham type. The failure of flexible couplings to render the most satisfactory service is not due to any fault of the couplings but to an attempt to apply them where the conditions are altogether too severe.

Too great an angularity or too much offset between the connected members will usually cause the working parts of the couplings to rub and become heated, which means a loss of power. However, extreme cases can be more or less efficiently handled by using two couplings instead of one, connected by an intermediate shaft. This allows greater offset and greater angularity between the driver and the driven shafts. In one design of coupling, the amount of misalignment permissible when using this arrangement is ¼ inch per foot of the intermediate shaft.

Types of Flexible Couplings

There is a wide variety of flexible coupling designs; most of them consist essentially of two flanged members or hubs, fastened to the shafts and connected by some yielding arrangement. These flanges may in some cases take the form of long sleeves, or they may be little more than connected disks. The flanges or other main coupling members are connected in various ways: They may be joined loosely with a rubber disk between them to permit change in position, or they may be connected by flexible pins constructed by laminations similar to a leaf spring; they may employ a connecting disk made of an insulating material with lugs alternately arranged on opposite sides, or they may include a flexible spoked-wheel construction with the spokes made of laminated springs and engaging slots in a spider. Again, they may be connected by flat links hung from pins on two circles with the circles of pins on one member located on the driver and the other circle of pins on the driven member, or they may interlock and have rubber cushions or springs located between them. In other cases, they may be machined to engage each other through a set of sliding blocks contained within them; or they may be connected in any of a variety of other ways. One design of flexible coupling having the connecting members in the form of sleeves instead of flanges consists of one heavy coil spring

as a driver and a smaller spring attached to the driven member. The smaller spring fits inside the larger one and is driven by friction.

Each type is a suitable transmitter of power, under reasonable conditions, and each contains some meritorious points of design. In general, it should be pointed out that the best results are most likely to be obtained where the couplings are of simple construction. Those that have as few working parts as possible and that are not too large, are desirable, provided they are capable of performing all the functions that a flexible coupling is intended to perform.

Factors Affecting Flexible Coupling Design

In designing flexible couplings, points that demand attention are the amount of power to be transmitted; the speed at which the machine, fan, blower or other device is to be driven; the likelihood of overload; the type of drive, that is, whether it is constant, intermittent or reversing; and special conditions regarding the operation of the machine that might affect the drive.

It has been stated that the construction should be as simple as possible; this will lessen noise and operating troubles and will make installation, adjustment, and replacement of worn parts easy. An ideal coupling would be one that could be installed and then forgotten. Certain types of couplings are designed to run without lubrication, but in most cases, means for lubricating the working parts are provided, especially where the design contains sliding members. Such a coupling, if run dry, wastes power. Some manufacturers recommend a soft graphite grease as a lubricant, while others prefer heavy cylinder oil. The choice, however, and in fact, the question of whether a lubricant needs to be used at all, is primarily a matter of coupling construction.

The members of a flexible coupling are usually attached to the shaft by means of keys, set-screws, or both. It is dangerous, however, for the heads of set-screws to project and for the ends of keys to extend beyond the hubs of the flanges. When set-screws can just as well be dispensed with, this should be done, and when not, safety set-screws should be used. The coupling should not only be capable of driving in both directions, but it should also be able to make sudden stops, quick reverses, and should provide for a small amount of end play. End play, especially in the case of a direct-connected motor-driven machine, is necessary, because it allows the armature shaft of the motor or generator to center the armature in the magnetic field.

A close-connected coupling is an advantage, since it reduces the leverage between the operating parts. Silent operation is always a desirable feature in any transmission unit, and the simpler the coupling construction, the more likely it is to be noiseless. Balance has a good deal to do with the efficiency of flexible couplings, because they frequently operate at high speeds and consequently are subject to more or less vibration, the effect of which may best be minimized by a balanced construction. The simpler designs may not have certain features that may be considered desirable, such as automatic adjustment to compensate for increasing loads and to take care of exigencies such as overload. But it is questionable whether a complicated coupling with automatic features is preferable to a simpler construction which gives little or no operating trouble after the coupling has once been installed.

End Thrust and Balance

Flexible couplings should be so designed that no end thrust is developed, as this will prevent motor end play, and cause the motor armature to run out of its magnetic center. This is an important matter where couplings are used in connection with herringbone gears. In designing or purchasing flexible couplings, it is important to see that the contacting surfaces do not, through wear, develop a thrust which will cause loss of power and possible shutdown.

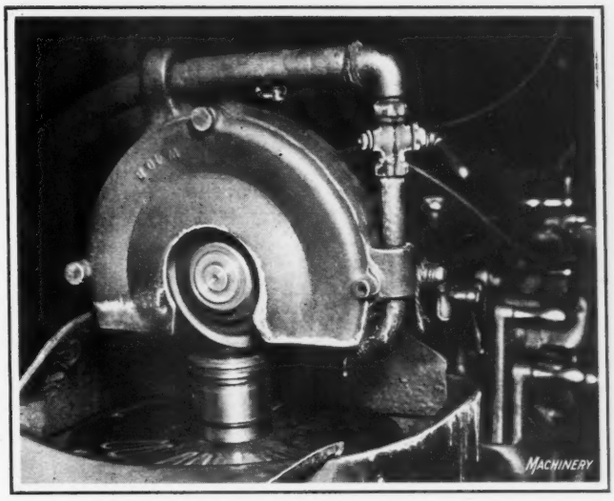
The question of balance is an important matter in coupling selection or design, as an increasing number of couplings are used in connection with steam turbines, high-speed motors, and many other classes of machinery. It is not sufficient that the coupling be perfectly balanced when installed, but it must remain in balance after wear has taken place.

As the majority of flexible couplings are used in connection with machinery that was formerly belt-driven, it is desirable to introduce a certain amount of resiliency in the coupling to take the place of that which was formerly supplied by the belt. Where ball-bearing motors are used to drive geared machinery or other shock loads, this is very important, as it relieves the balls from blows which may cause damage. This coupling resiliency reduces repairs to motor windings by freeing them from shocks and jars. As mentioned, several couplings on the market accomplish this more or less perfectly through the use of leather, rubber, or canvas under tension or compression and also through the use of coil or leaf springs. Couplings employing springs should always be lubricated, if possible; otherwise, the springs will cause loss of power.

* * *

FINISHING HEAD ENDS OF OVER-SIZE PISTONS

The head end of cast-iron pistons for automobiles is usually finished by facing, this operation being performed at the same time that the outside diameters are turned. For this work automatic lathes are commonly employed. An unusual method of finishing the ends of over-size pistons is employed in the factory of the Houpert Machine Co., Long Island City. Large quantities of semi-finished over-size pistons are carried in stock, and are taken from stock as the demands require, and finished by grinding both on

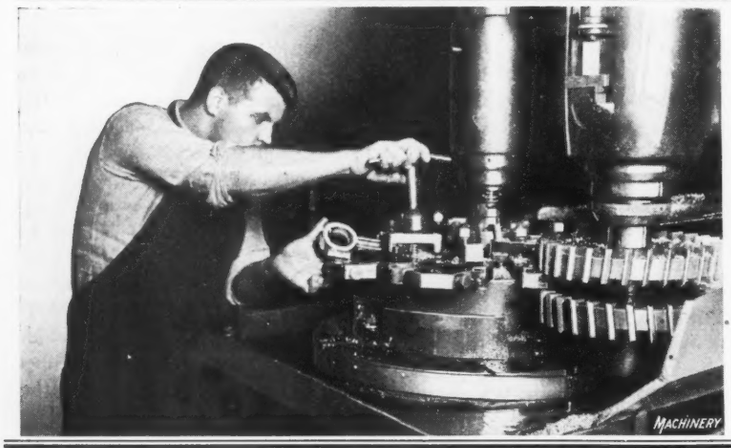


Grinding the End of Over-size Pistons

the cylindrical part and on the closed end. The latter operation is the one to which attention is here directed. The purpose of this novel means of finishing is to prevent an excessive accumulation of carbon—a precaution which is rarely taken, even by the manufacturers of automobile motors.

The operation itself is extremely simple, and is performed on a No. 2 Heald rotary surface grinder, as shown in the accompanying illustration. The piston is centered on the magnetic chuck while the wheel is traversed across the piston to the center. Only about 0.004 or 0.005 inch of metal is removed in this operation, it being necessary merely to produce a highly finished surface on the end on which carbon cannot readily accumulate. A 24-C grain Norton wheel, grade F is used in this operation.

Making Wills Sainte Claire Connecting-rods



Methods Employed in the Plant of the Taft-Peirce Manufacturing Company, Woonsocket, R. I., for Machining High-grade Automobile Connecting-rods — First of Two Articles

By FRED R. DANIELS

THE connecting-rods of the Wills Sainte Claire eight-cylinder automobile engine are made from a molybdenum alloy steel—a material which is capable of withstanding the severe service to which automobile connecting-rods are subjected. The rods of opposing cylinders are yoked together at their crankpin ends by a bronze sleeve, the crankpin bearing of the plain rod illustrated in Fig. 1 being assembled in the fork of the rod shown in Fig. 2. In machining both these styles of rods at the plant of the Taft-Peirce Mfg. Co., Woonsocket, R. I., some unusual equipment is employed in order to attain the required accuracy. This and a concluding article to be published in December MACHINERY, will follow the manufacturing processes step by step.

The two rods are identical in the design of the straight H-section and the wrist-pin boss, and certain finished dimensions (including the center distance between holes) are also the same; this makes it possible to use the same or very similar tooling and fixtures for several operations on both styles. The forked rod is forged solid at the gap end, as indicated by the dot-and-dash outline in Fig. 2; on that account some extra operations are required for finishing this end. Both forgings are inspected, heat-treated, and straightened before machining.

Milling the Piston-pin and Crankpin Bosses

The first machining operation on both rods is straddle-milling the piston-pin and crankpin bosses. This is done on a Becker continuous rotary milling machine equipped with the familiar type of multiple fixture commonly used for operations of this nature. (See the heading illustration.) An allowance is left on the thickness of the large bosses for a subsequent grinding operation by means of which the side surfaces are finished. This allowance is a little greater for the springy forked rod than for the solid plain rod. The cutting speed for milling both rods is 90 feet per minute. If serious deflection of the forging results from this straddle-milling operation, it is, of course, important to straighten the connecting-rods before any further machining operations are performed on them.

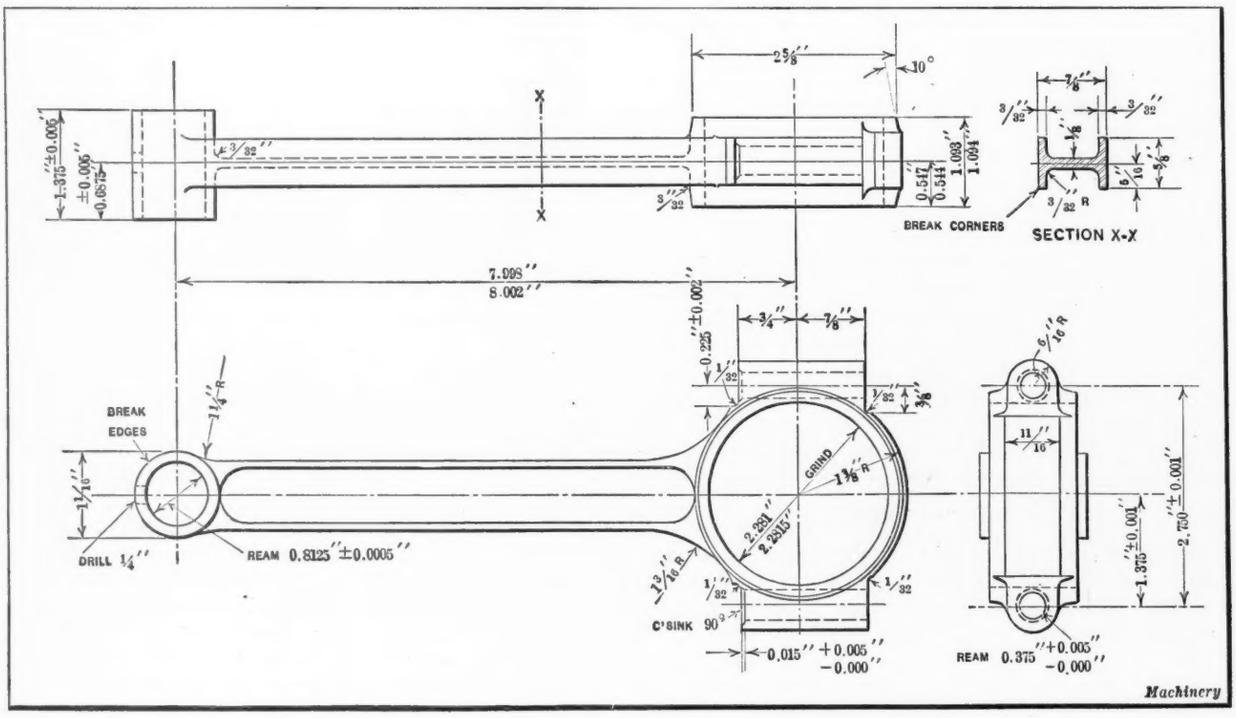


Fig. 1. Diagram illustrating Details of Design of the Plain Connecting-rod

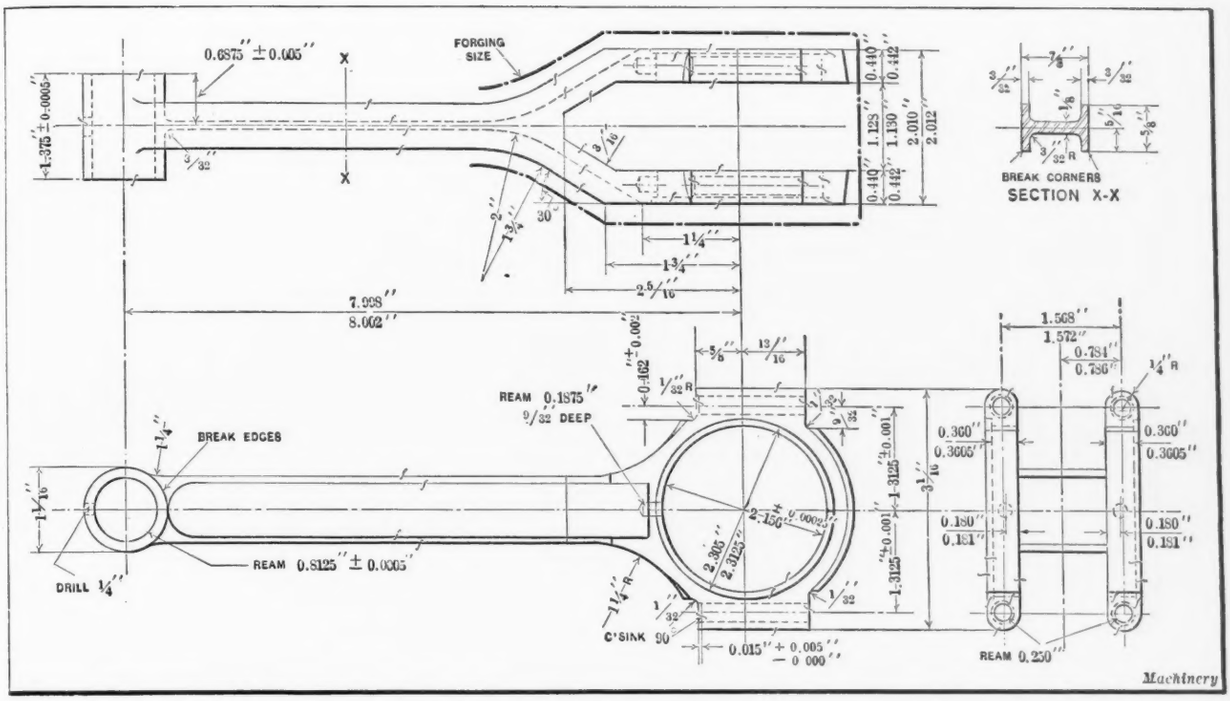


Fig. 2. Diagram illustrating Details of Design of the Forked Connecting-rod

The forked rod is now subjected to an extra operation, a light grinding cut being taken on the faces of the large boss to correct any inaccuracy that may have resulted from the milling. This leaves both rods with the sides of the bosses parallel and with about 0.023 inch of stock left for finishing. The piston-pin and crankpin holes are drilled and rough-reamed on a Foote-Burt four-spindle drilling machine, leaving about 0.013 inch of stock on the small holes for grinding, and approximately 0.085 inch on the large holes, which are bored before grinding. For drilling and reaming, the rods are securely located against V-blocks at the piston-pin end. Four-lipped drills are used for the larger holes, this type of drill being better adapted for this work than an ordinary twist drill, especially when a tough material like molybdenum steel has to be drilled.

Rough-milling the Gap in the Forked Rod

The next operation on the forked rod consists of rough-milling the gap. Fig. 3 shows the rod before and after this operation. Three cuts are taken, the roughing cut being performed with the equipment illustrated in Fig. 4, which is mounted on a Briggs milling machine. There are two fixtures on the table, one at each end, so that the inserted-tooth milling cutter can be alternately fed to the forging in each fixture. The crankpin end of the rod is located in the fixture by means of two expansion arbors which extend into the previously reamed hole from the sides. These arbors are operated by a knurled knob on each side of the fixture and locked by wing-nuts. The piston-pin end of the connecting-rod is located by an oval-section stud on the fixture. This stud fits in the hole in a vertical plane, but permits of slight variations in the center distance between the bosses which may exist at this stage of the manufacture. It may be mentioned that in all the milling fixtures used before grinding, this method is used to compensate for center distance discrepancies. The depth of the gap is limited positively by a stop located under the machine table at each end, and while the table is feeding toward one stop, the

Fig. 3. Forked Rod before and after milling

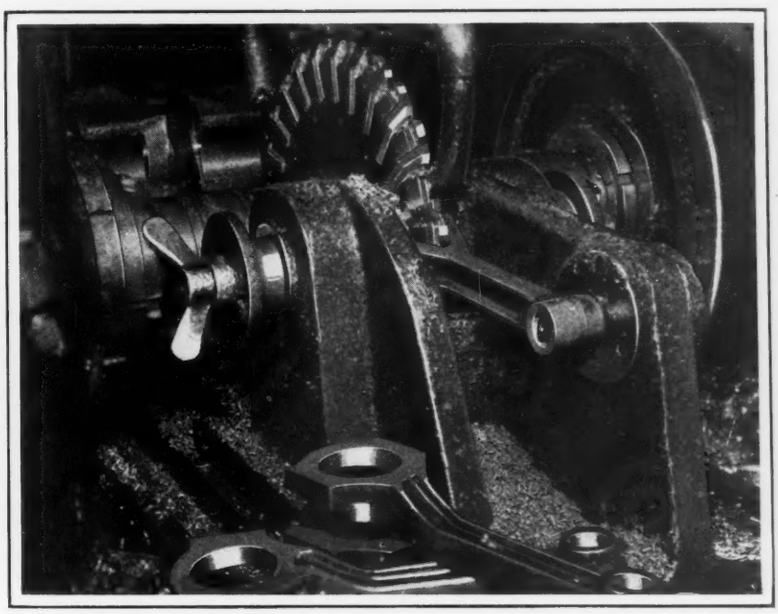


Fig. 4. Set-up used in milling Gap in Forked Connecting-rods

operator loads a rod into the opposite fixture. It is the usual custom for one operator to have charge of two machines.

A special inserted-tooth milling cutter, 11 inches in diameter, of the design shown in Fig. 5, is used in milling the gap. The two disks in which the blades are set are made of machine steel and pack-hardened. Both contain slots for the insertion of 25 blades, secured in the slots by straight slabbed pins, set at a 5-degree angle. All the blades in one disk are right-hand, and all those in the other, left-hand. The disks are screwed together with a sheet steel shim, 0.030 inch thick, between them, thus forming a staggered-tooth milling cutter. The type of blade used is shown in the detail view at the top of the illustration, from which it will be seen that the angular cutting edges of blades of opposite hands will produce the tapered shape at the crotch of the gap. In rough-milling the rod, about 0.020 inch of stock is left on each side of the gap for subsequent finishing. This stock is removed in two milling operations performed after the large hole has been finish-bored, which is done after the caps have been cut off and fitted. In the finish-milling operations on the gap, the set-up used is similar to that shown in Fig. 4, except that the milling cutter blades do not have angular cutting edges for finishing the crotch. In finish-milling, from 0.008 to 0.010 inch of stock is removed.

an indexing fixture and four formed cutters. The fixture accommodates two forked rods mounted as shown, a spacing collar being used between each gap to maintain parallelism of the two bosses. The rods are secured in position by a strap. At the completion of one traverse of the table, the fixture is swung in a vertical plane, through 180 degrees, to bring the bosses on the opposite side of the work to the cutters. The knob at the front of the fixture operates a spring locking pin, and during the indexing a simple turn of the knob withdraws the pin and keeps it disengaged. An angular surface on the index-pin boss acts as a cam when the knob is turned, withdrawing the pin and compressing the spring, thus preventing engagement of the pin until the knob is again turned by hand. The finished rods shown lying on the table of the machine give an idea of the nature of this operation and the appearance of the work after it is completed. The cutter speed for this operation is 80 feet per minute, and the table feed, ½ inch per minute.

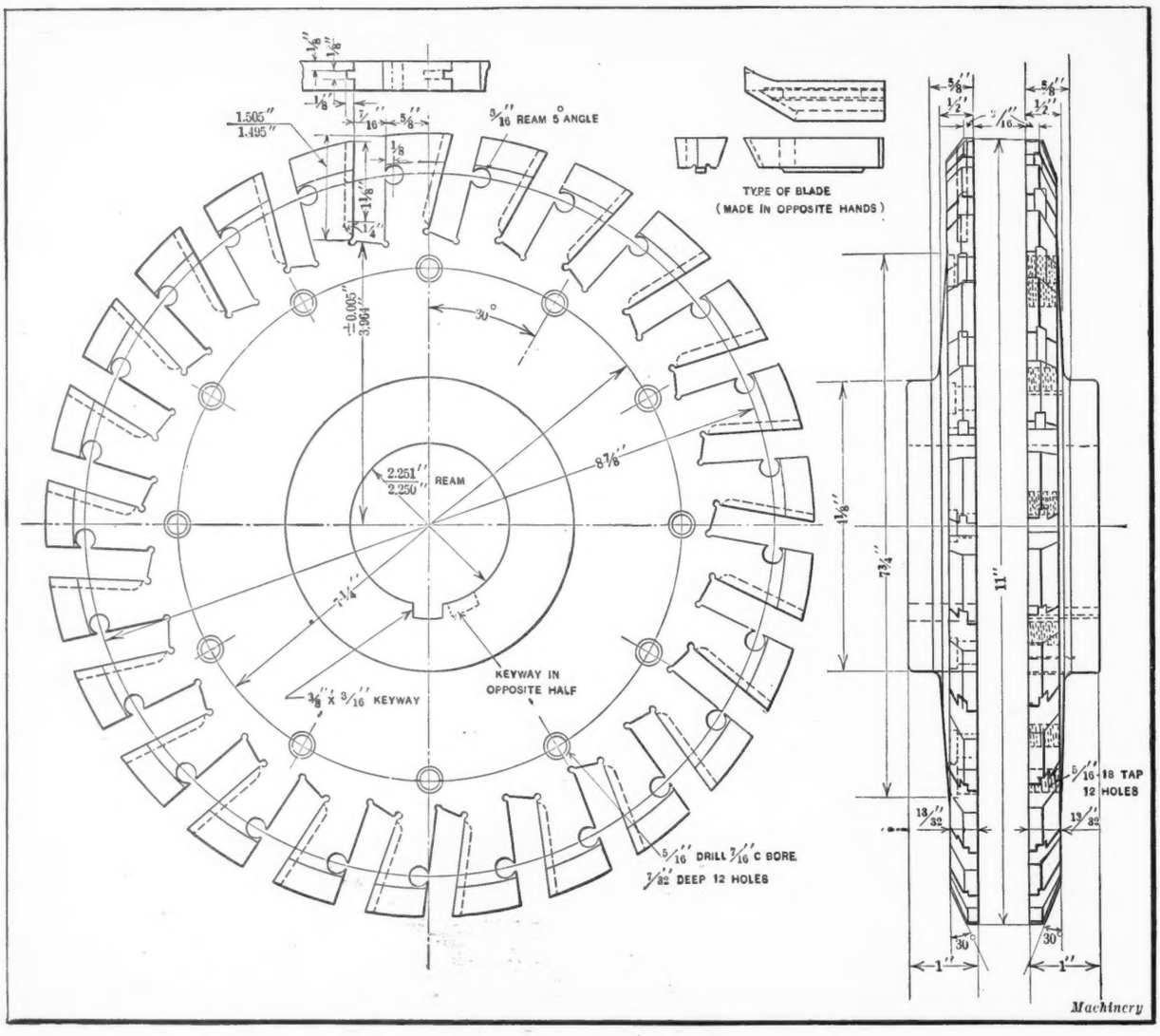


Fig. 5. Staggered-blade Cutter for milling Gap in Forked Connecting-rods

Milling the Bolt Bosses

The operation of milling the convex surfaces of the bolt bosses on the forked rod is illustrated in Fig. 6. This work is done on a No. 2 Brown & Sharpe milling machine, using

For the corresponding milling operation on the plain rods, a No. 1 B Milwaukee milling machine is employed, the set-up for which is illustrated in Fig. 7. Three rods are milled at a time by using spacing collars between them and fastening them on the arbor of the fixture by the simple means shown. The rods are placed on the arbor with the piston-pin ends extending alternately in opposite directions. They are supported in the proper horizontal position by a screw and check-nut. Flat springs which engage the piston-pin bosses prevent each rod from lifting from its seat on the screw head, due to the thrust of the cutters. This

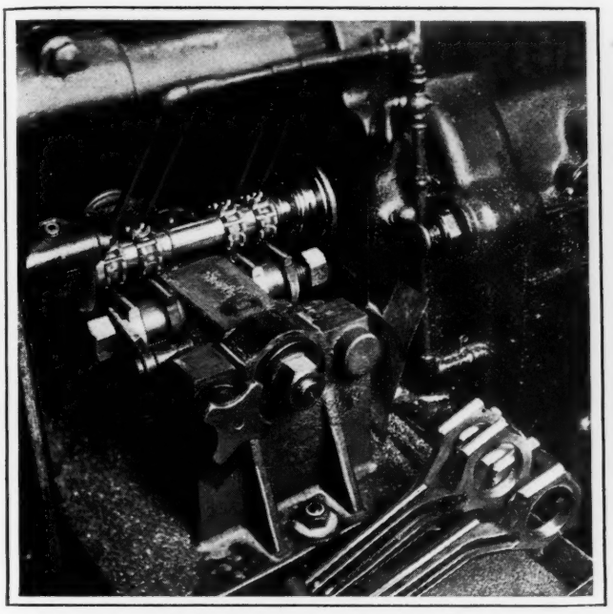


Fig. 6. Milling the Bolt Hole Bosses of Forked Rods

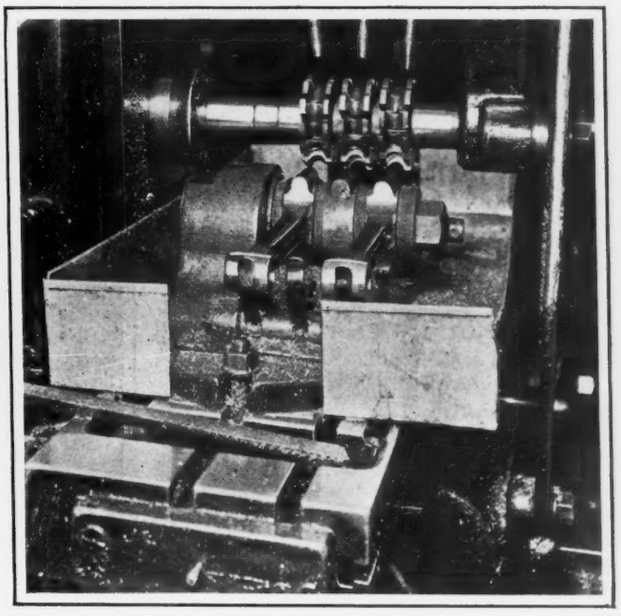


Fig. 7. Milling the Bolt Bosses of Plain Connecting-rods

fixture is not of the indexing type, and the rods must be reversed after each traverse of the machine table to mill the bosses on the opposite side. The cutter speed is 50 feet per minute, and the table feed, ½ inch per minute.

Milling Operations on the H-section

For milling the groove and edges of the H-section on the forked connecting-rod, a unique type of milling fixture is used. It will be seen from Fig. 2 that this section curves out to join the crankpin boss. It is to provide for this curve, which is indicated by the 1¾- and 2-inch radii that this fixture is especially designed. The operation is done on No. 1 Brown & Sharpe milling machines, the set-up for which is illustrated in Fig. 8. Two machines are attended by one operator.

The fixture occupies the entire table of the machine and has an auxiliary table, hinged on stud *A*, which passes through the fixture. Cam surfaces on the under side of the auxiliary table and a cam-roll over which its free end rides as the machine table travels back and forth, impart the necessary vertical movement to the auxiliary table for milling the curves. The auxiliary table has flanges extending on both sides to engage rolls *B* at the top, and to steady the work-holding part of the fixture. The roll over which the lower cam surfaces ride keeps the auxiliary table in contact with the upper rolls throughout the movement of the machine table. An eccentric sleeve is provided at the pivot, which enables longitudinal adjustments to be made when necessary.

The work, which is partially hidden in the illustration by the gang of milling cutters, is located on studs, the piston-pin stud being elliptical, as on the fixture previously described. The cut taken in this operation is rather heavy, and for this reason an auxiliary brace *C* has been attached to the machine to furnish additional outboard support for the over-arm. By using two machines the work is transferred from one to the other for milling opposite sides of the rods.

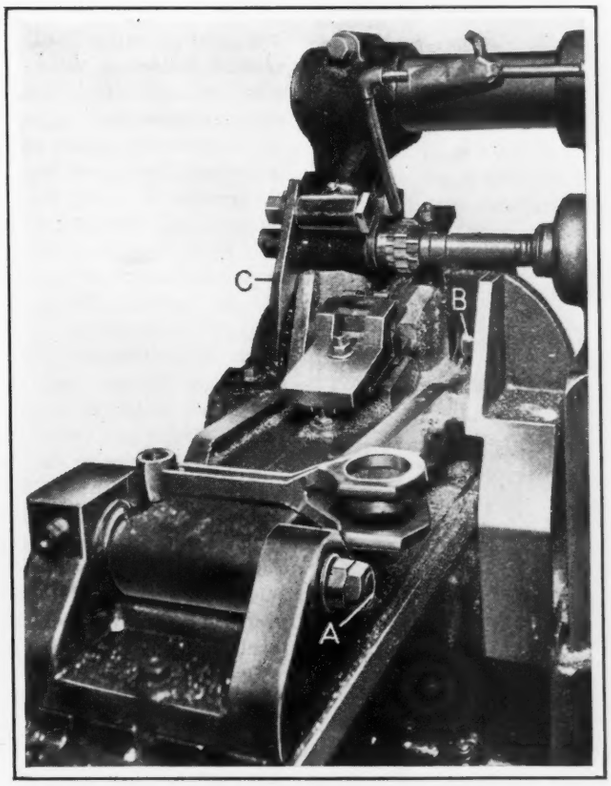


Fig. 8. Hinged Fixture used in milling H-section of Forked Rod

For the corresponding operation on the plain rods, it is not necessary to use this special fixture. The work is located on a fixture by means of studs, and a gang of three milling cutters is used, the same as in the operation just described. For both rods a cutter speed of 85 feet per minute and a table feed of 2 inches per minute are employed.

Milling the Rods to Final Shape

The piston-pin boss (except for its ends) and the curved surface which joins it to the top of the H-section on both styles of rods are milled on a No. 1½ Milwaukee vertical milling machine equipped with a gear-operated fixture which revolves the work past the cutter. A fixture of identical design is used to mill the complete cylindrical surface where the boss projects from each side of the H-section. The surfaces machined in these two operations complete the shape of the piston-pin boss and blend it into the straight part of the connecting-rod. The type of fixture used is illustrated in Fig. 9, where it is shown in use on the cylindrical ends of the boss. By turning the capstan wheel, the fixture is revolved to pass the work under the end-mill which sweeps inside the projecting ends of the boss and simultaneously cleans off what stock may remain from the previous operation on the edges of the ribs adjacent to the boss.

The only difference in the set-up for milling the remainder of the boss is in the vertical position of the table, it

being necessary only to raise the table until the cutter can sweep the entire length of the boss. The radius of the cutter is 1¼ inches to correspond to the radius of the curve which joins the boss to the H-section. Thus, as the fixture is swung around, the cutter first mills this curved surface on one side of the rod, then the entire length of the boss along the front, and finally the curved surface on the opposite side of the H-section. The operation has been performed on the work shown on the fixture. The cutter speed is 85 feet per minute.

There is one other important milling operation on the plain rods that is not required on the forked type, and that is form-milling the 1⅜-inch radius (see Fig. 1) at the large end of the rod. For this purpose, a No. 3B Milwaukee milling machine is employed, equipped with a fixture and a gang of formed cutters, as illustrated in Fig. 10. The fixture accommodates twelve rods, six on each side, three in the front and three in the rear. This enables a high production to be attained. By the time the six rods at one end are finished, the operator is ready to feed the table across to the rods on the other end, and while these are being milled he replaces the finished rods with unmachined ones. The cutter speed is 70 feet per minute, and the table feed, ½ inch per minute.

The second installment of this article will describe the operations required to complete the connecting-rods. These include the method of machining the cap-screw holes grinding the fitting surfaces for the crankpin bearing cap, refinishing after assembling the caps, grinding the piston-pin and crankpin bearing holes, and final inspection.

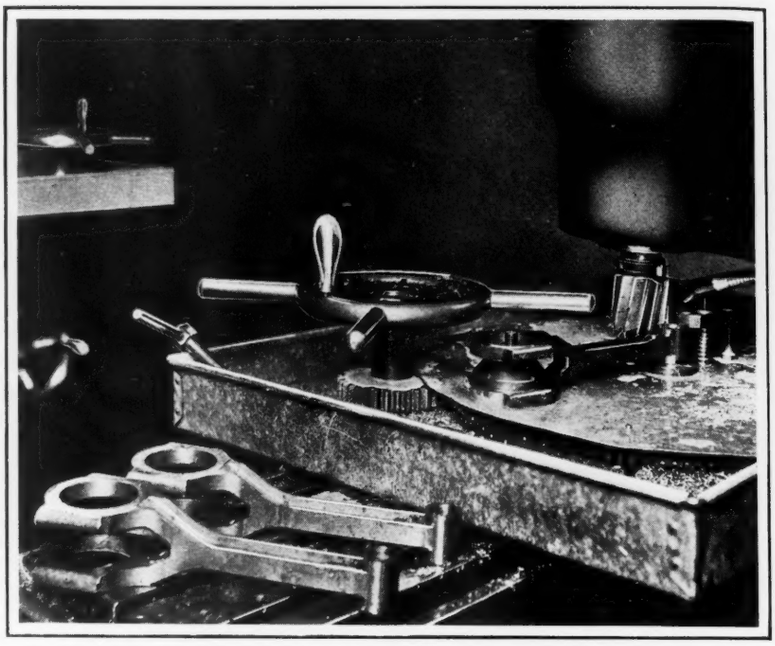


Fig. 9. Gear-operated Fixture used in milling the Piston Wrist-pin Boss

* * *

TECHNICAL LITERATURE AND THE ENGINEERING STUDENT

Is the engineering student being properly trained in the uses of the available technical literature, both that in periodical and in book form? How can he be trained to appreciate the value of engineering literature while in college? These questions are answered by E. H. McClelland, technology librarian of the Carnegie Library of Pittsburg, in an interesting article published in *Engineering Education*, in which the methods that should be used to interest students in studying engineering journals are referred to. To quote from the article, "With many students the appeal will be stronger if the assigned problems have a commercial or industrial trend. Set a student to determining what companies manufacture lathes, or locomotives, and in what part of the country the plants are. What are some of the largest companies and what is their organization? Who is the president or the purchasing agent of each? What journals would offer the most fertile field for advertising their product, and what kind of trade literature (catalogues, house-organs, etc.) do they issue? Not all this information can be found readily—that regarding smaller companies is particularly elusive—but the search for information of this nature will properly call into use a set of tools and aids entirely different from those used in obtaining information on engineering or purely scientific topics. This sort of problem in some form comes to libraries almost daily, which proves that it must be of an essentially practical character."

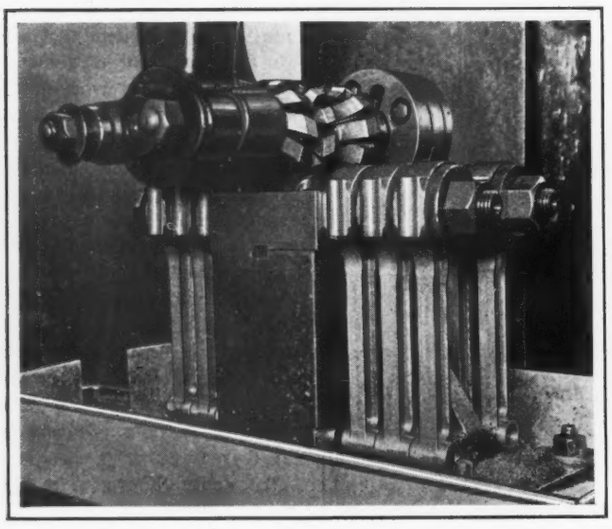


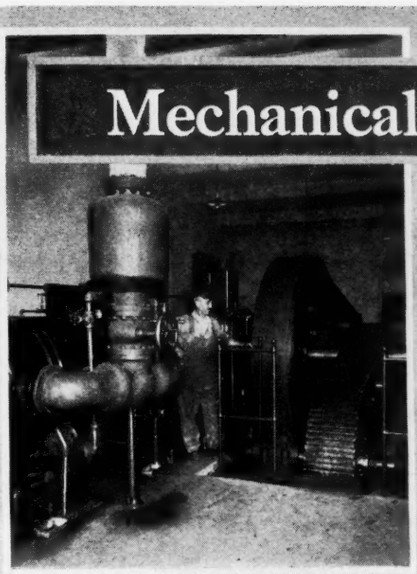
Fig. 10. Milling Machine Set-up for form-milling End of the Large Boss on Plain Rods

A good practical problem for acquainting students with current literature is to ask them to imagine themselves ordered to a foreign country remote from libraries and book stores, and ordered to assemble and take with them a good working library on any engineering subject, be it a chemical laboratory or a machine-building plant.

The way in which to test the general acquaintance of the student with the best engineering magazines in the field is to read to them the titles of some rather specialized articles and have them indicate the branches of engineering to which the articles belong and the name of the journals in which the articles would be expected to appear. Another question that would make it necessary for the student to become acquainted with a variety of the more important technical literature available would be to ask him to name the most important handbooks in different engineering fields in use in the United States. He should not only be acquainted with books, but also with the leading publishers of engineering books, and the author of the article puts as a test question to the student to name for each field an American publisher who is prominent in the field of (1) chemistry, (2) electrical and mechanical engineering, (3) works on machine shop practice, and (4) manuals on operation of prime movers.

There is no doubt that both students in engineering colleges and men engaged in practical engineering and machine shop work would be greatly benefited by a more intimate acquaintance with the sources of information available to them in current mechanical literature, both in magazines and in technical books.

Mechanical Transmission of Power



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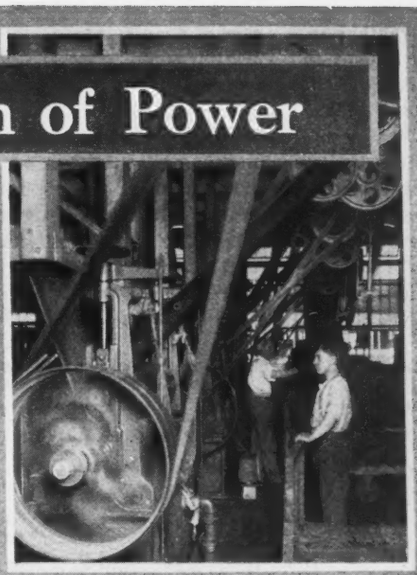


Power-transmitting Capacities of Different Types of Gearing—Concluding Installment

SINCE gearing provides the means of transmitting motion and power in a large percentage of mechanical appliances, its practical application must necessarily be based upon a great variety of conditions. Because of these numerous variations, gears differ greatly, not only as to type, design, and size, but also as regards accuracy, methods of mounting, etc.; consequently, in determining by calculation the power-transmitting capacities of gearing in general, as covered in this review of the subject, it is necessary to consider as far as possible average conditions.

Frictional and Toothed Gearing

The term "friction gearing" is commonly applied to that type consisting of a driver made of some substance such as fiber or leather and arranged to operate by rolling in contact with a metallic driven wheel. The driving and driven wheels may be either cylindrical for driving parallel shafts or conical for driving shafts at an angle; when speed variations are required, a small driving disk may be arranged to revolve in contact with the side of a comparatively large driven disk, which also provides for reversing the rotation merely by shifting the driver to the opposite side of its central position on the driven disk. With the latter arrangement, pure rolling contact is not obtained when using a driver of cylindrical form, since it makes contact with the driven disk at various diameters.

Friction gearing provides a smooth, uniform drive, but toothed gearing is superior for most purposes because of its positive action and greater power-transmitting capacity. The latter may also be designed to transmit much more power, and at the same time insures maintaining the same relative positions between the driving and driven members, which is important for many classes of mechanism. The common forms of gearing for connecting parallel shafts are spur gears, single helical or twisted gears, and double helical or herringbone gears.

Spur gears are the simplest to design and cut, and meet the requirements for a large percentage of parallel shaft drives. Single helical gears are used extensively for electric railway service, as the helical teeth are conducive to smooth continuous action which prolongs the life of the gearing as compared with spur gears. The helix angle of the teeth is quite small (usually from 7 to 10 degrees), so that the end thrust is well within the capacity of the oil film on standard armature end-thrust collars and on axle collars. The standard helix angle adopted by the R. D. Nuttall Co. for railway gears is 7½ degrees.

Herringbone or double helical gears neutralize the end thrust, since they have right- and left-hand sections, and such gears are especially applicable for high velocities and ratios in connection with turbine reduction gearing or for installations requiring a minimum of vibration and noise.

Gear Ratios and Speed Variations

Proportioning a train of gears to obtain a given velocity ratio, or possibly a given series of speeds, is frequently encountered in the design of geared transmissions. When the problem is simply that of obtaining a given velocity ratio, and when the latter is so large that more than one pair of gears should be used, a uniform reduction between the different pairs is conducive to the highest efficiency. Whenever this arrangement is practicable, the ratio of each pair in a train may be determined by extracting the root of the total ratio. If there are two pairs of gears, extract the square root; for three pairs, extract the cube root, etc. For example, if the total ratio between the first driving and the last driven gear is to be 125 to 1 and three pairs of gears are to be used, the ratio of each pair should preferably equal 5 to 1, since $\sqrt[3]{125} = 5$.

In designing gear combinations for varying spindle speeds or feeding movements, it is general practice, among machine tool builders particularly, to vary the speeds in geometrical progression, successive speeds being obtained by multiplying each preceding term by a ratio or constant multiplier. Thus, if the slowest speed is 50 revolutions per minute and the ratio is 1.3, the succeeding speeds will equal

$$50 \times 1.3 = 65$$
$$65 \times 1.3 = 84.5$$
$$84.5 \times 1.3 = 109.8$$

When the fastest speed F and the slowest speed S in a series are known and also the total number of speeds N, the ratio may be determined by the well-known formula:

$$\text{Ratio} = \sqrt[N-1]{\frac{F}{S}}$$

Since logarithms would ordinarily be used for the extraction of this root, the ratio may be obtained as follows:

Rule—Subtract the logarithm of the slowest speed from the logarithm of the fastest speed and divide the difference by the total number of speeds minus 1; the result will equal the logarithm of the ratio.

In actual practice, the exact progression obtained may be modified slightly to permit using gears of a certain diametral pitch. For machine tool transmissions, the speed ratio should, as a general rule, be between 1.3 and 1.5, as otherwise there will be either too small or too great a difference

between successive speeds. There would be no practical advantage in a series of speeds varying by small increments equivalent to a ratio of say, 1.1, whereas, if the ratio were 1.7 or possibly 2, the changes from one speed to the next would be excessive. Feeding mechanisms may be designed for ratios of 1.2 or less, depending on the type of machine.

Speeds of machine tool drives and especially feed changes are sometimes varied according to "chromatic scale progression," with a ratio of either 1.4142 or 1.189 in case a lower ratio is required. The first ratio is the square root of 2, and the second the fourth root of 2. The object of using these particular ratios is to obtain a series of speeds or feeds containing the even ratios, 2, 4, 8, 16, etc.

Designing Spur Gears for Transmitting a Given Horsepower

When it is required to know the diametral pitch for transmitting a given horsepower, this may be determined directly by the following formula, based upon the well-known Lewis formula:

$$P = \sqrt{\frac{S_s A V Y \pi}{H \times 55\ (600 + V)}} \qquad (1)$$

in which

P = diametral pitch;

S_s = allowable static unit stress or the stress at "zero velocity" = 8000 for accurately cut cast-iron gears, 15,000 for steel containing about 0.30 per cent carbon, 25,000 for steel containing about 0.50 per cent carbon, 9000 for semi-steel, 5000 for rawhide, bakelite, formica, and condensite, and 12,000 for phosphor-bronze;

A = a factor which is usually 3 or 4 for cut gears, the assumption being that the face width is to equal 3 or 4 times the circular pitch, which is the general practice;

V = pitch-line velocity in feet per minute—preferably limited for average conditions to about 1200 feet per minute for cut spur gears of ordinary quality to avoid excessive noise;

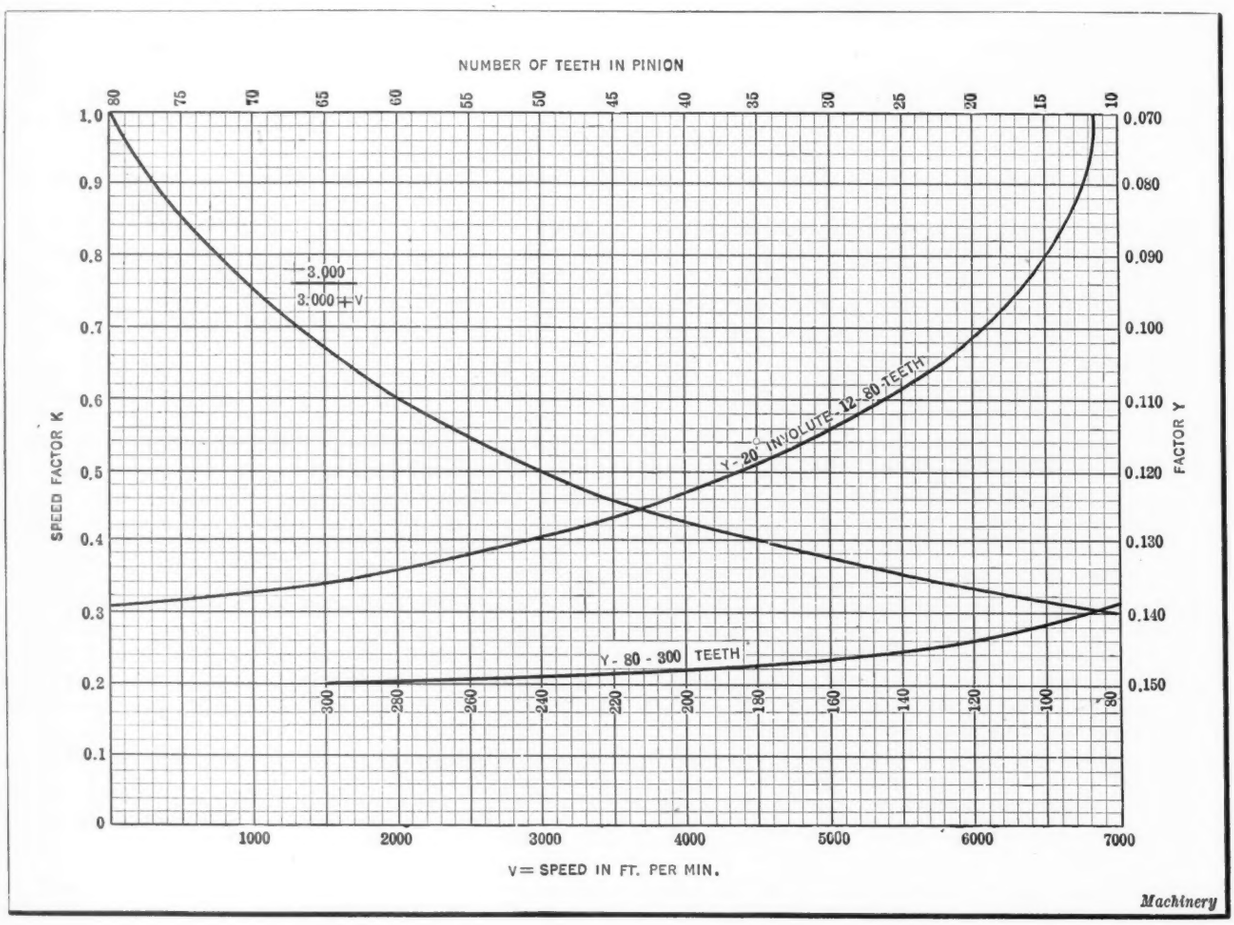
Y = Lewis formula outline factor for a given diametral pitch and pressure angle (see MACHINERY'S HANDBOOK, page 595); and

H = horsepower.

When the diametral pitch and velocity are known, the horsepower that can be transmitted by a gear of given material may be determined by the following formula, which is also derived from the Lewis formula:

$$H = \frac{S_s V F Y}{P \times 55\ (600 + V)} \qquad (2)$$

in which F = face width in inches. The notation otherwise is the same as for Formula (1).



Factors used in determining Power-transmitting Capacity of Herringbone Gears

When gears have stub teeth, the two pitches indicating the proportions of the teeth represent also the approximate increase in strength, as compared with standard teeth. Thus a stub-tooth gear of 6–8 pitch would transmit a load equal to approximately 8/6 of the safe load for a standard gear of 6 diametral pitch. When the teeth have full shrouding, they are about 100 per cent stronger, ordinarily, and 50 per cent stronger for half shrouding.

Power Transmitted by Herringbone Gears

Accurately cut herringbone gears represent the most efficient type of geared drives for parallel shafts. Gears of this type are adapted for higher velocities and ratios than spur gears. Accurate and well-made herringbone gears are often operated at pitch line velocities of from 3000 to 5000 feet per minute in connection with steam turbine reduction gearing, and the ratios may be 10 to 1 or higher for some installations.

In designing herringbone gears, the total face width, including the clearance space at the center (for gearing having such spaces), should be equal to at least six times the circular pitch for a 23-degree helix angle, to insure proper overlapping of the teeth or continuous contact. The following formula for determining the power-transmitting capacity of herringbone gears is recommended by a committee of the American Gear Manufacturers' Association.

In this formula

W = allowable tangential load in pounds at pitch line;

S_s = working stress in pounds per square inch for zero velocity = 15,000 for chrome-nickel steel heat-treated, 12,500 for 0.50 carbon forged steel, 10 000 for 0.30 carbon forged steel, 7500 for cast steel, and 4000 for cast iron;

P' = circular pitch;

Y = factor obtained from curve on accompanying chart;

K = speed factor, also obtained from the accompanying chart $= \frac{3000}{3000 + V}$.

The notation otherwise is the same as for spur gears.

$$H = \frac{WV}{33{,}000} \qquad W = S_s P' FYK \text{ for well-oiled gears}$$

For grease lubrication, multiply W by 0.8 to 0.62, depending upon the degree of lubrication.

The preceding horsepower formula takes into account the wearing quality of the gearing as well as the strength, and it is applicable to helix angles of about 23 degrees and a pressure angle of 20 degrees on the axial section of the hob.

To illustrate the application of the formula, assume that the capacity of a chrome-nickel steel pinion, heat-treated and having 33 teeth of 2½ diametral pitch, is to be determined for a pitch-line velocity of 1860 feet per minute, a face width of 28 inches, and oil bath lubrication. Then,

$$W = 15{,}000 \times 1.256 \times 28 \times 0.118 \times 0.62 = 38{,}550$$

$$H = \frac{38{,}550 \times 1860}{33{,}000} = 2170 \text{ horsepower, approximately}$$

Helical gears have several inherent advantages as compared with the spur type. First, the action is distributed over more than one tooth, and all phases of tooth engagement, such as sliding and rolling contact, occur simultaneously, which tends to equalize wear and preserve the correct tooth shape. The load is transferred gradually and uniformly as successive teeth come into engagement, and the bending action resulting from the tooth load is less than for a spur gear, because the line of contact extends diagonally across the meshing teeth; the tooth load of a helical gear, however, is higher because of the angular position of the teeth, and the normal tooth section is, of course, smaller than that of a spur gear of the same circular pitch.

Power Transmitting Capacity of Helical Gears

Helical gearing for driving shafts which are not intersecting and not parallel is generally considered a rather treacherous type to use, when the amount of power is relatively high. In most installations, the power transmitted is much less than the maximum capacity of the gearing, and whenever the amount of power is likely to be anywhere near the maximum, it is preferable to use worm-gearing, the worm having as many threads as are required to give the desired velocity ratio. Helical gears which have caused trouble due to abrasion resulting from the small contact area and highly localized pressure, have often been replaced by worm-gearing with satisfactory results.

The advantage of the larger bearing surfaces of worm-gearing is illustrated by the following example and practice: A pair of helical gears were made, the smaller gear being made of hardened steel and the larger gear of cast iron. The helix angle was satisfactory, but when the gears were operated under working conditions they began to heat immediately and were worn out in a few hours. A second set was beginning to heat and show signs of wear, and would evidently have worn out as rapidly as the first set, but it was suggested that the cast-iron gear which was partly worn, be polished. After this was done, thus converting the helical gear partly into a worm-wheel, the gears operated without further difficulty. In this case the helical gears were changed by abrasion into worm-gearing, practically, and polishing the surfaces of the teeth merely arrested the wear that had started. Whenever there is any doubt about the power-transmitting capacity of helical gearing, it is not advisable to rely upon calculations, but to determine this capacity by an actual test with all running conditions, as regards speed, lubrication, and load, duplicated.

Application of Bevel Gears

Bevel gears are of the most important class of gearing for connecting shafts located at an angle. The straight-tooth form is applied to angular drives on practically all classes of mechanism, and the spiral type bevel gear for certain special applications, as, for example, the rear axle drives for automobiles.

The power transmitting capacity of bevel gearing may be determined by a formula based on the Lewis formula. A factor is introduced which represents approximately the relation between the strength of a bevel gear and that of a spur gear having the same number of teeth and pitch. There is also another modification in that the outline factor Y is not selected for the actual number of teeth in the gear.

In this formula C = the pitch cone radius; otherwise the notation is the same as that used for spur gears.

$$H = \frac{S_s VFY\,(C - F)}{55 \times PC\,(600 + V)}$$

To determine the outline factor Y, first divide the number of teeth by the cosine of the pitch cone angle. The quotient represents the number of teeth in an equivalent spur gear, and the table of outline factors for spur gears is used.

Capacity of Spiral Bevel Gears

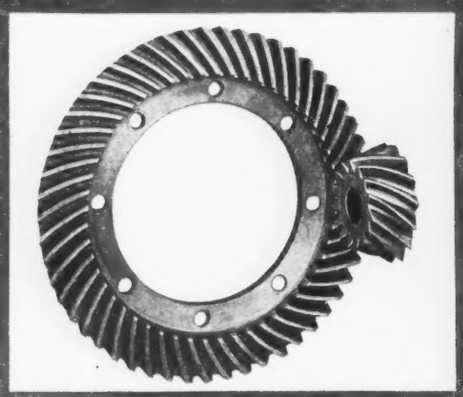
Spiral bevel gears have a load-carrying capacity that is somewhat greater than that of straight-tooth bevel gears of similar proportions. The difference in capacity, however, is not very great, and the formula for straight-tooth gears may also be applied to the spiral bevel type. One of the principal reasons that spiral bevel gears are slightly superior to the straight-tooth form as power transmitters is that there are more teeth in contact and the load on any one tooth is less. Another reason is that the load is never concentrated on the point of a tooth throughout its whole length. When there is contact at the point at one end, the contact is toward the flank at the other end, and the average height from the root, at which the load is applied, is much less than the total height of the tooth. The smoothness of operation is another favorable factor tending toward greater load capacity, as in the case of herringbone or double-helical gearing for connecting parallel shafts.

The tooth of a spiral bevel gear has to take both the transmitted load and the thrust load. This total load A equals the transmitted load B divided by the cosine of the spiral angle. For a 30-degree spiral angle, the total load is about 1.15 times the transmitted load. This additional tooth load on a spiral bevel gear tooth, as compared with a straight tooth, is more than offset by the increased number of teeth in contact.

While the tooth thickness of the spiral bevel gear is less than that of the straight gear, the length of the curved tooth is correspondingly greater, so that the sectional area on the pitch cone surface is practically the same for the straight and spiral forms of teeth of corresponding pitch.

* * *

According to figures published by the Department of Commerce, 246,941 automobiles were produced in August as compared with 81,693 in January, each month having shown a considerable increase.



Cutting Spiral Type Bevel Gears

By FRANKLIN D. JONES

Principles of Spiral Bevel Gear Cutting—Operation and Adjustment of Generators Designed for Cutting Gears of Different Sizes

SPIRAL type bevel gears have been used widely in automobile rear axle drives in preference to bevel gearing having straight teeth. There has also been an increasing demand for this type of gearing for other purposes. The spiral design operates more smoothly than bevel gears with straight teeth and has certain other advantages. The relation between spiral and straight tooth bevel gearing is practically the same as the relation between ordinary spur gears and helical gears applied to parallel shafts. The teeth of spiral bevel gears are not a true spiral, although the actual curve, when developed on a plane, closely approximates the spiral curve. A tooth having a curvature that meets practical requirements can be cut readily on a manufacturing basis, and there is no good reason for attempting to obtain a true spiral.

Two Methods of Cutting Spiral Bevel Gears

There are two general methods of cutting spiral bevel gears on Gleason generators. One is known as the "standard" or "single-side" method, and the other as the "spread-blade" method. With the standard method all the teeth are formed first on one side (when taking the finishing cuts); then both gear and cutter are adjusted slightly, and the opposite sides are finished. This method is recommended when a relatively small number of gears are to be cut—say fifty or less. The spread-blade method is so named because the cutter used has its blades spread far enough apart to form both sides of a gear tooth space at the same time. Since all the gear teeth are formed while the blank is indexed one revolution, instead of two revolutions as with the standard method, there is a saving in the cutting time for a gear of 40 per cent or more. This does not apply however, to the mating pinion, assuming that the latter is cut by the standard or two-side method, which is the usual practice. Most spiral bevel gears are now cut by the spread-blade method, which is recommended for cutting duplicate gears on a quantity basis. The generator to be described may be used for either method of cutting if equipped with a cutter adapted for the method employed.

Spiral Bevel Gear Generator

A 15-inch Gleason generator designed for cutting spiral type bevel gears is shown in Fig. 1. The action of this machine in forming the tooth curves, is based upon the same fundamental principle as that of the generators used for gears having straight teeth; that is, the cutter and gear blank are rolled together in order to generate the tooth curves. A rotary type of cutter, however, is used on the spiral type of generator to form curved teeth. The cutter-head *A* has a number of equally spaced blades or cutters, and the curvature of the gear teeth depends upon the radius of the circle with which the cutting edges coincide. Every other blade around the cutter-head cuts on the outside, and the remaining blades cut on the inside. It is evident then that the concave sides of the teeth are formed by the outer edges, and the convex sides by the inner edges. Each blade is ground on the cutting side to the pressure angle of the gear, except for a slight modification referred to later, and the opposite side has clearance. These inner and outer blades have top rake, and slope in opposite directions, or away from the cutting edges, to give a better cutting action.

This machine is designed primarily for finishing teeth that have been roughed out on another machine, although it may also be used for roughing cuts. The generator is used for stocking out gears by changing the feed-cam and running the machine without any rolling motion. When pinions are roughed out on this machine, the generating motion and finishing feed-cam are used, so that the machine set-up, with the exception of the cutter and cutter settings, is the same as for finishing. Separate stocking cutters having different point widths are usually required for the gear and the pinion. The finishing cutters will be the same for each member when the standard or single-side method of cutting is used, but will be different when the gears are cut by the spread-blade method.

Action of Spiral Type Bevel Gear Generator

A geared drive is used to roll the cutter and work together, instead of the master and crown gear segments employed on the straight-tooth generators. Column *B* supporting the cutter-spindle is mounted on a cradle *C* which has circular, segment-shaped ways and receives a rolling motion through a worm and a large worm-wheel segment. The amount of rolling motion is regulated by change-gears and a reversing mechanism making a fixed number of turns in each direction. This reversing drive is also connected to the work-spindle through permanent gears, change-gears, and a worm and worm-wheel segment, which transmits motion to the work-spindle through the indexing worm-gearing. The relative amount of rolling motion between the cutter and the work is controlled by compound change-gears located in the drive to the work-spindle. The cutting or generating of the tooth curves occurs while the cutter and work are rolling upward, and during the downward rolling motion a feed-cam swings the gear away from the cutter. The indexing movement then takes place, after which the gear is returned to the cutting position. This feed-cam is timed with the reversing mechanism previously referred to.

The cutter-head can be adjusted both vertically and horizontally for different cone distances and spiral angles. Scales and graduating dials reading to thousandths of an

inch indicate the extent of these adjustments. As the cutter blades are shortened in grinding, the cutter-spindle may be adjusted lengthwise to locate the outer ends of the blades in a vertical plane coinciding with the center of the machine. If the center of the cutter-head is below that of the work, when cutting a pinion, the cutter center will be located above the center of the work when cutting the mating gear, because the curvature of the pinion teeth must be in the opposite direction.

Determining Blank Dimensions and Angles

In spiral bevel gear calculations, the angle of the blank, root angle, outside diameter, pitch diameter, and pitch cone angle are all calculated the same as for straight-tooth bevel gears. The same values are also used for the diametral or circular pitch. These gears are cut for 14½-, 17½-, and 20-degree pressure angles. When the angle is 14½ degrees, under-cutting of the pinion is avoided by using long and short addendum teeth. Pinions for automobile drives were formerly made with an addendum equal to 0.7 of the working depth, the addendum of the mating gear being 0.3 of the working depth. The latest practice is to proportion the teeth for each ratio to give the best rolling conditions and still avoid undercut, taking into account the number of teeth in the gear and the pinion, and the pressure angle.

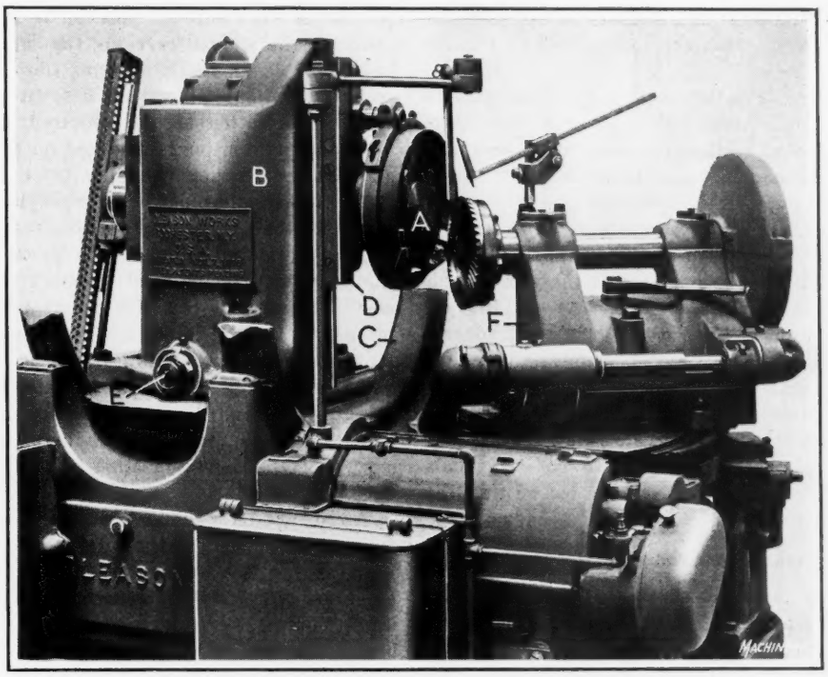


Fig. 1. Cutting a Spiral Type Bevel Gear on a 15-inch Gleason Generator

Left-hand cutters should always be used for finishing, so that the thrust of the cut will oppose the rolling movement of the work and give better control during the generating process. Roughing cutters, whether used on this machine or on a special rougher, should be of the same hand as the gear; that is, for a left-hand pinion and a right-hand gear a right-hand roughing cutter should be used. Then the cutter will always work from the small end of the tooth toward the large end when roughing the gear, and the thrust of the cut will be against the chucking plate. The "hand" of the cutter is determined by the direction in which it revolves, as seen from the rear side.

Because of the circular path followed by the blades when cutting spiral bevel gears, the pressure angle on the outside and inside edges is modified; thus the angle is not exactly 14½ degrees, 17½ degrees or 20 degrees, as the case may be. The angle of the inside-cutting blade is somewhat greater than the nominal pressure angle, and that of the outside-cutting blades is somewhat less. However, the effective pressure angle of the engaging teeth, measured with relation to the pitch cone surface, is the same for the engaging teeth of the gear and pinion. It is evident, therefore, that the effective pressure angle is not the same as the angle of the cutter blade. The cutter settings are so computed as to make the effective pressure angles equal for the gear and pinion teeth in mesh.

A series of finishing cutters is provided for each pressure angle. These are designated by numbers, and the selection depends upon the spiral angle desired. The sine of the pitch-line spiral angle obtained with a given cutter is found by dividing a constant by the sum of the block or dedendum angles of the gear and pinion, expressed in minutes. The constant is equal to the number of cutter multiplied by 20, the cutter number being a measure of the pressure angle correction.

When both gear and pinion are cut by finishing each side of the tooth space separately, the same cutter is used for the gear and pinion. When both sides of each tooth space on the gear are finished simultaneously by the spread-blade method, a cutter with the blades separated enough to obtain the proper tooth thickness must be used for the gear. A cutter of standard dimensions is used for the pinions, since the latter have each side of the tooth space finished separately, except in the case of small gearing, as explained later.

The method of measuring the angle of spiral is indicated by the diagram Fig. 2, which also shows the meaning of the term "lead" as applied to this type of gearing. To insure quiet operation, the angle should be sufficient to give a lead that is equal to from 1¼ to 1½ times the circular pitch. A spiral angle of about 30 degrees is usually the most satisfactory for automobile gears of 4 to 5 diametral pitch. For finer pitches, an angle between 25 and 30 degrees is sufficient. The angle should never be greater than about 35 degrees.

In setting up the machine for a new gear-cutting job, the cradle supporting the cutter-head should be at the center of the generating or upward rolling movement. The cam that imparts a swinging motion to the work-head should also be in its central position, as determined by a zero line on the cam and a fixed pointer. When the cam is in this position, if the cradle is not central, it can readily be adjusted. The rolling motion of the cradle is controlled by change-gears, and the extent of this movement must be determined by trial. For instance, a movement of 45 to 50 degrees will probably be necessary for a flat gear, whereas about 23 degrees is sufficient for a pinion of 3 or 4 to 1 ratio. The motion will be less for a pinion of higher ratio. The only requirement is that the cutter shall have rolled clear of the tooth before the generating movement is reversed. Another set of change-gears, selected for different combinations by referring to a table accompanying the machine, is used to give the proper relation between the rolling movements of the cradle and work.

Checking Angle of Rolling or Generating Motion

The ratio of the compound change-gears which govern the relative amount of rolling motion between the cutter and work, depends upon the pitch cone angle of the gear or pinion to be cut. If the angle through which cradle *C* (Fig. 1) moves, is divided by the angle through which the gear

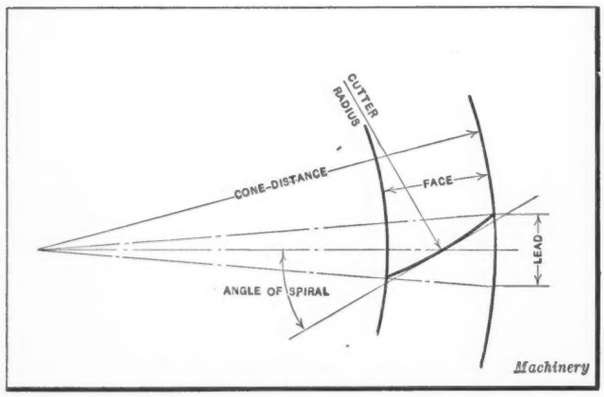


Fig. 2. Diagram showing how Angle of Spiral Bevel Gear Tooth is measured

rolls, the quotient should equal the sine of the pitch cone angle of the gear. In determining the change-gear combinations as listed in the table, it is necessary to consider the fixed or permanent gears, which are represented in the calculation by a constant.

To illustrate the relation between the generating motions and the angle of the gear, assume that the gear is to have 49 teeth and the pinion 13 teeth. The tangent of the pitch cone angle of the gear equals the number of teeth in the gear divided by the number of teeth in the pinion, or $49 \div 13 = 3.769$; hence, the angle of the gear is 75 degrees 8 minutes. If the angular motion of the cradle is assumed to be 30 degrees, then the angular motion of the work equals 30 ÷ sin 75 degrees 8 minutes = 30 ÷ 0.96653 = 31.038 degrees. The rolling motion of the work during the 30-degree movement of the cradle can be checked by means of graduations and a vernier scale located at the outer end of the work-spindle. In this instance the cradle is moved through an arc of 30 degrees, and the vernier scale will show whether or not the angular motion of the gear to be cut equals 31.038 degrees, which is the correct amount for cutting the gear of this particular combination.

Shop Test for Generating and Indexing Movements

In making the shop tests for checking the ratio of the rolling movements, the machine is stopped when the cradle stands exactly on the 15-degree position. The vernier at the back of the work-head is then set at zero by turning the vernier-carrying dial. After securing this dial by a thumb-screw, the machine is started and run until the cradle stands at exactly 15 degrees on the other side of the zero position. The angular movement of the work-spindle on the opposite side of zero is then noted, and should correspond with the "test roll" given in connection with the table of ratio change-gears. The foregoing ratio test is for use in cutting gears. The same method is followed for cutting pinions, with the exception that the rolling movement of the cradle should be either 8 or 6 degrees each side of the center.

The indexing movement can be checked in connection with the test for the ratio of the roll. The vernier dial at the end of the work-spindle should be left as previously set. The machine is then allowed to run until the cradle has passed the lowest point in its rolling movement, and has rolled up to exactly the angular position at which it was set for the ratio of roll test, which is 15 degrees for gears, and either 8 or 6 degrees for pinions. The machine should now have completed one cycle and indexed one tooth, and the vernier reading at the end of the work-spindle should equal 360 degrees divided by the number of teeth in the gear or pinion to be cut.

Adjustments of the Cutter

The horizontal and vertical adjustments of the cutter relative to the cone center of the gear or pinion, differ somewhat for roughing and finishing cuts, although, as previously mentioned, spiral bevel gear generators are ordinarily used for finishing gears that have been stocked out on a machine designed especially for this purpose. When the sides of the tooth spaces are finished by taking separate cuts, the vertical position must be changed slightly, first for cutting the teeth on one side and then for the opposite side. The method of determining these adjustments depends not only upon the gears or pinions to be cut, but also on the method of cutting—that is, whether by the single-side or spread-blade method. In ordinary practice, the shop man is, of course, given the dimensions required for making these horizontal and vertical adjustments. The formulas needed for calculating these dimensions are supplied by the Gleason Works.

For adjusting the cutter horizontally, the column supporting the cutter is moved laterally on the cradle by means of an adjusting screw *E*, Fig. 1. A scale at the base of the column, reading to tenths of an inch, and a dial on the screw reading to thousandths are used in making these adjustments. The vertical position is regulated by raising or lowering the slide *D* carrying the cutter-spindle. This slide is adjustable along the face of the column, and a vertical scale, in conjunction with a dial on the crankshaft, serves to set the cutter at the required height.

Whenever a cutter is mounted on the spindle, either after sharpening or when changing from one cutter to another, the cutter-spindle must be adjusted lengthwise to locate the points of the blades in a vertical plane coinciding with the center of the machine or the apex of the pitch cone of the gear. A gage is used to check this adjustment. It is also necessary to test the radial position of each blade; in fact, it is very important to have all the cutting blades set at exactly the same radius, because if a high blade does most of the finishing, the teeth will have a series of flats formed on them. To secure a fine adjustment, each blade rests on a wedge which may be moved in or out by a screw, thus changing slightly the radial position of the cutting edge.

There are two non-adjustable master blades in each cutter-head, one of which cuts outside and the other inside. In adjusting the blades for cutting outside, the dial indicator used for testing is first set to zero when in contact with the outside-cutting master blade. All the other outside blades are then adjusted to give zero readings, after which the inside-cutting blades are set with reference to the master blade in the same manner. In sharpening a cutter, the radial position of the cutting edge is affected. In order to reduce the time required to true up the cutter to a minimum, it is desirable to have each blade sharpened so that its cutting edge is on the same radius as the master blades. The Gleason spiral cutter grinder is equipped with a worm-wheel so that each blade can be indexed around, and its correct angular distance from the master maintained.

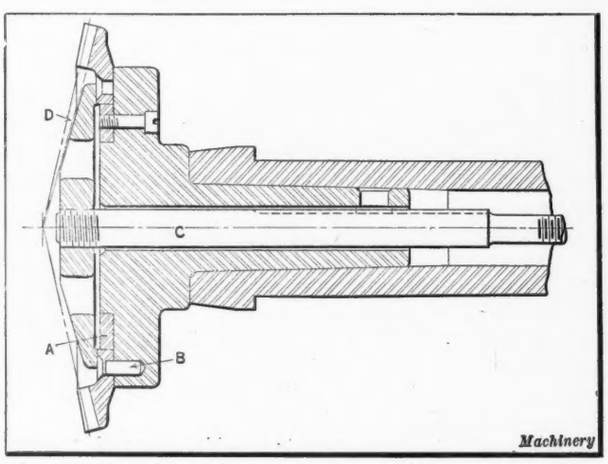


Fig. 3. Arbor for holding Ring Gears on Spiral Bevel Gear Generator

Swinging Movement of Work-holding Head and its Angular Position

The angular movement of the head *F* (Fig. 1) which carries the work-spindle is obtained by subtracting the root angle of the gear or pinion from the face or blank angle (as measured from the axis) and then adding one degree for clearance. This angular movement is regulated by an adjustment of the cam-lever through which motion is transmitted to the head. Graduations on the side of the lever are referred to in making this adjustment.

In order to locate the gear at the correct angle relative to the cutter, and at the proper distance from the center of the machine, the work-spindle head is first set to the face angle of the gear (one-half the included blank angle). Graduations on the segment-shaped base are used in making this setting. A feed change-gear is next removed to permit running the cutter by hand, while the rest of the machine is idle. The work-spindle head is then moved forward carefully until the ends of the cutter blades just scrape the face of the gear blank. The reading on a scale at the side of the work-spindle head is then noted and marked down, as this reading is needed later in adjusting the cutter for generating the top sides of the gear teeth. The head is now moved backward for clearance and is set to the root angle.

Regulation of Feed and Speed Changes

The speed of the entire machine, except the cutter drive, is regulated by the feed change-gears, which control the rate of feed or the time per tooth, in accordance with the pitch of the gear and the material. For low-carbon nickel-steel commonly used in automobile practice, and for diametral pitches up to 4, the time per tooth, when using the spread-blade method, may vary from twenty to thirty-five seconds for the gear, and is somewhat longer for the pinion. The cutter speed is regulated by speed change-gears, according to the nature of the work. For nickel-steel a speed of 90 to 100 feet per minute is a fair average.

Setting Cutter for Finishing Top and Bottom Sides of Teeth

When the convex and concave sides of the teeth are finished by separate cuts, the cutter-slide is first set in the correct vertical position for finishing the top sides of the gear teeth. Then, with the cradle at the center of the generating or upward rolling movement, the work-spindle head is set, by means of the scale along its base, to the reading previously obtained at the time when the gear blank was adjusted until the cutter blades just scraped the face.

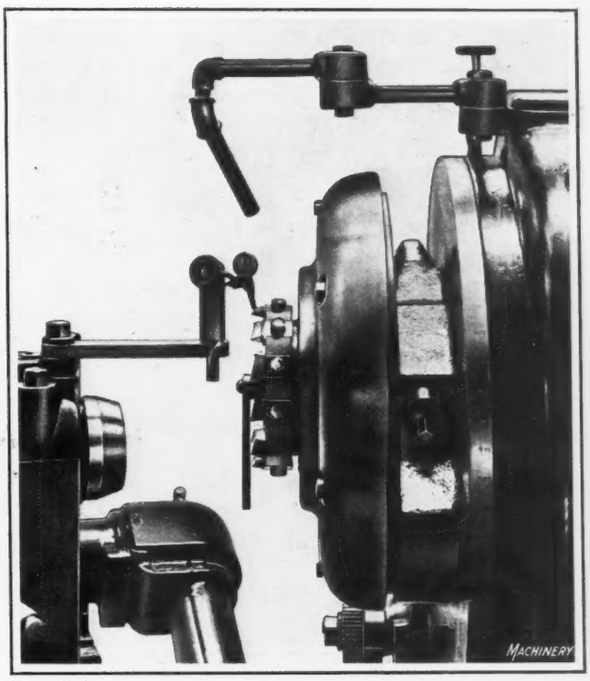


Fig. 5. Testing Radial Positions of Cutter-head Blades

To do this, it is necessary to disengage a clutch on the worm-shaft of the index mechanism until a roughed out tooth space in the gear blank is in alignment with the cutter blades. The indexing worm is revolved slowly until the top side of the gear tooth just touches a cutter blade which operates on this side. The index clutch is then closed, and the machine is run until the gear is swung out far enough to clear the cutter. The clutch is next disengaged, and one half is moved several notches relative to the other half, in order to shift the top side of the gear tooth toward the cutter. This adjustment should be sufficient to remove approximately one-half the stock left for finishing, and it must be found by trial.

After all the teeth have been finished on the top side, the vertical position of the cutter is changed for finishing the bottom side. The tooth thickness is regulated by disengaging the index-clutch and turning the work-spindle back enough to permit the cutter to true up the bottom side of one tooth. Two or three teeth are then cut, and the thickness measured; if necessary, repeated adjustments are made by means of the index clutch until the thickness is correct. By noting the adjustment of the clutch, which has a graduated ring that can be set to zero as a starting point, the same setting can be used for duplicate gears, provided no changes are made in the position of the cutter.

Adjustments when Both Sides of Tooth Space are Cut Simultaneously

When the spread-blade method is employed, the adjustments differ slightly from those made for the standard method. The work-spindle head is set to the proper angular and lengthwise positions, as previously described, but it is necessary to have only one cutter blade in the roughed out tooth space, in order to permit swinging the gear blank around until the bottom of a roughed out space is up to the point of the cutter blade. The work-spindle is adjusted for

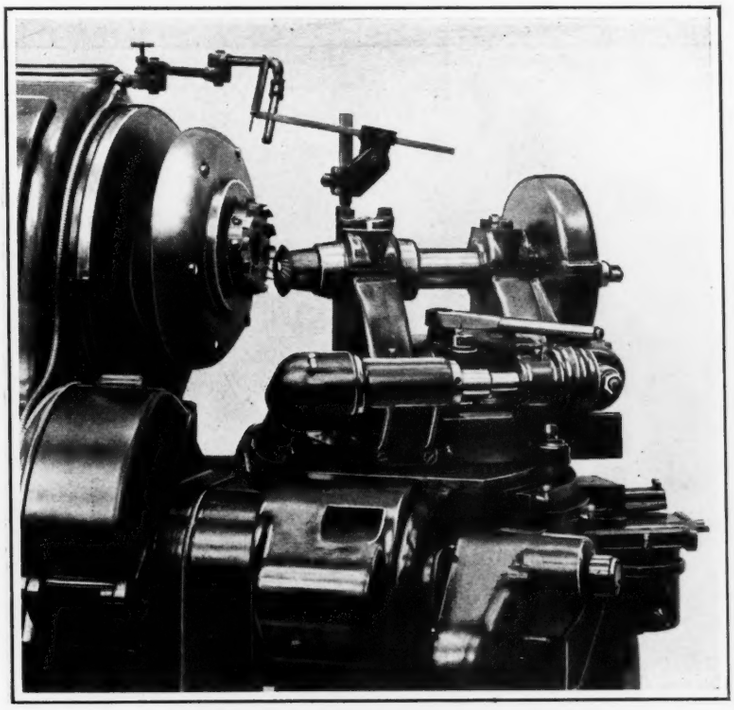


Fig. 4. Spiral Bevel Gear Generator of Eccentric Head Construction

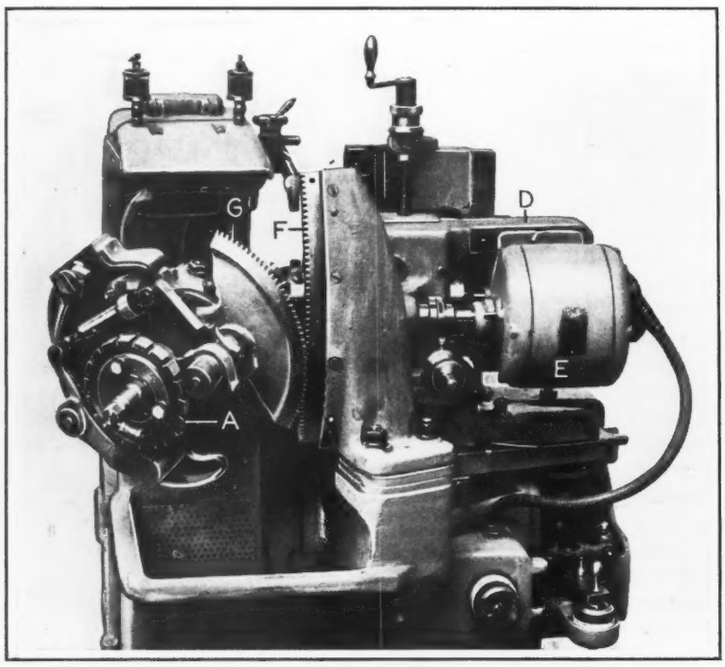


Fig. 6. Generator designed for cutting Small Spiral Bevel Gears

dividing the amount of stock that is removed from each side of the tooth space, by disengaging the index clutch and changing its position as may be required. As both sides of the tooth space are finished simultaneously, there is only one vertical position for the cutter. The tooth thickness depends upon the cutter dimensions, and cannot be regulated by the operator.

Method of Holding Spiral Bevel Gears

When cutting spiral bevel gears the work is ordinarily held either by a keyway previously cut or by a dowel-pin in the case of ring gears. A positive method of mounting is preferable, partly because the thrust of the cut is to some extent circumferential, and partly because the keyway or dowel provides a convenient means for locating the roughed-out gears on the generator, so that the amount of stock removed from opposite sides of the teeth by the finishing cuts is approximately equal and it is not necessary to use the stock dividing gage.

An arbor for holding ring gears on a spiral bevel gear generator is illustrated in Fig. 3. This arbor has a centering plate *A*, which fits closely into the bore of the gear, and the latter is prevented from turning by pin *B*. The clamping plate is engaged by the threaded end of drawbolt *C*. An arbor of this kind must be designed so that all projections clear the root line *D* of the gear.

Spiral Bevel Gear Generator of Eccentric Head Construction

The 8-inch Gleason spiral bevel gear generator shown in Fig. 4 operates on the same general principle as the 15-inch machine previously described, but the design is somewhat different, particularly the construction of the cutter-spindle head. On the smaller machine a circular generating plate having a bearing around the entire circumference serves the same purpose as the segment-shaped cradle of the larger machine. The work-spindle is mounted eccentrically in a drum-shaped member, which is also located eccentrically within the generating plate. With this eccentric construction, the cutter can be adjusted vertically and laterally relative to the center of the gear blank, the same as though it were mounted on a column and slide having lateral and vertical adjustments, as on the larger machine. The generating plate and work-spindle are rolled together to provide a generating movement which is controlled by suitable combinations of change-gears.

In setting up the machine, many of the adjustments are practically the same as described for the 15-inch size. Owing to the eccentric construction, the cutter is set according to angular graduations instead of by linear dimensions. The "eccentric angle" is indicated by degree graduations on the eccentric drum and minute graduations on the dial of the adjusting handwheel. In setting up this machine, the cutter-spindle must be adjusted lengthwise, so that the points of the blades are in a plane with the cone center of the machine, this adjustment being the same as when setting up the larger generator.

The cutter blades must also be adjusted carefully to the same radial position. Fig. 5 illustrates the dial indicator used for checking their position. When a second cutter-head is available, this adjustment may be made on a cutter-truing fixture in order to reduce the idle time of the machine, but when cutting pinions this test should preferably be made while the cutter is on the machine, because the effect of a high blade is more pronounced on the profile of a pinion tooth.

Cutting Small Spiral Bevel Gears

The Gleason machine shown in Figs. 6 and 7 is used for cutting small spiral bevel gears having pitch diameters ranging from 3 inches for a 1 to 1 ratio, up to 4 inches when the ratio is 4 to 1. These gears are of the class used on sewing machines, motion picture machines, and various other kinds of apparatus. This machine usually finishes the teeth from the solid in one operation, the spread-blade method being used; the method whereby one side is cut at a time is sometimes employed.

This machine differs from the other types of Gleason generators described, particularly in regard to the generating motion. All of this motion is applied to the gear being cut, instead of rolling the gear and cutting tools together as is done in the other generators. The action applied to the work is similar to that of a bevel gear rolling on a

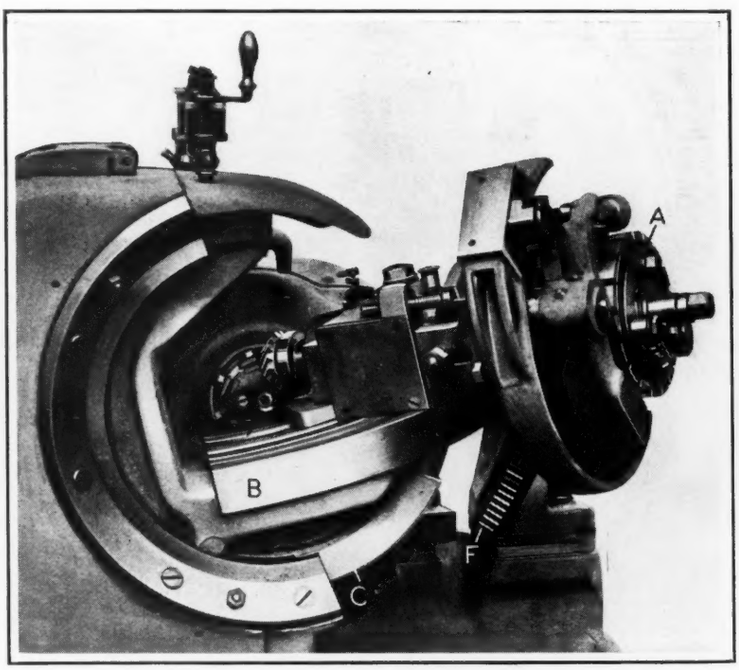


Fig. 7. View of 4-inch Generator, showing Cutter and Gear

stationary crown gear. The other generators for both stationary and straight-tooth bevel gears are so designed that the action is similar to that of a bevel gear being revolved by a crown gear.

The diagrams *A* and *B*, Fig. 8, illustrate the difference between the two motions. When the small spiral bevel gear generator is at work, the axis of the revolving cutter remains in one position (see diagram *A*), while the gear blank rolls bodily about an imaginary crown gear *c*, far enough to permit the cutter to generate a tooth space. Arrow *a* indicates the swinging movement of the work about the axis of the crown gear, and arrow *b* illustrates the rotation of the work about its own axis. When the generating motion is applied to both gear blank and cutter, as indicated by diagram *B*, the axis of the gear blank remains stationary and the gear turns about this axis as the cutter is given a swinging movement, just as though the working part of the cutter were the tooth of a crown gear rotating in mesh with the gear being cut. The two circles *d* and *e* represent the swinging movement of the cutter, which must be great enough to permit generating a tooth space. The 15-inch spiral bevel gear generator has the generating motion illustrated by diagram *B*.

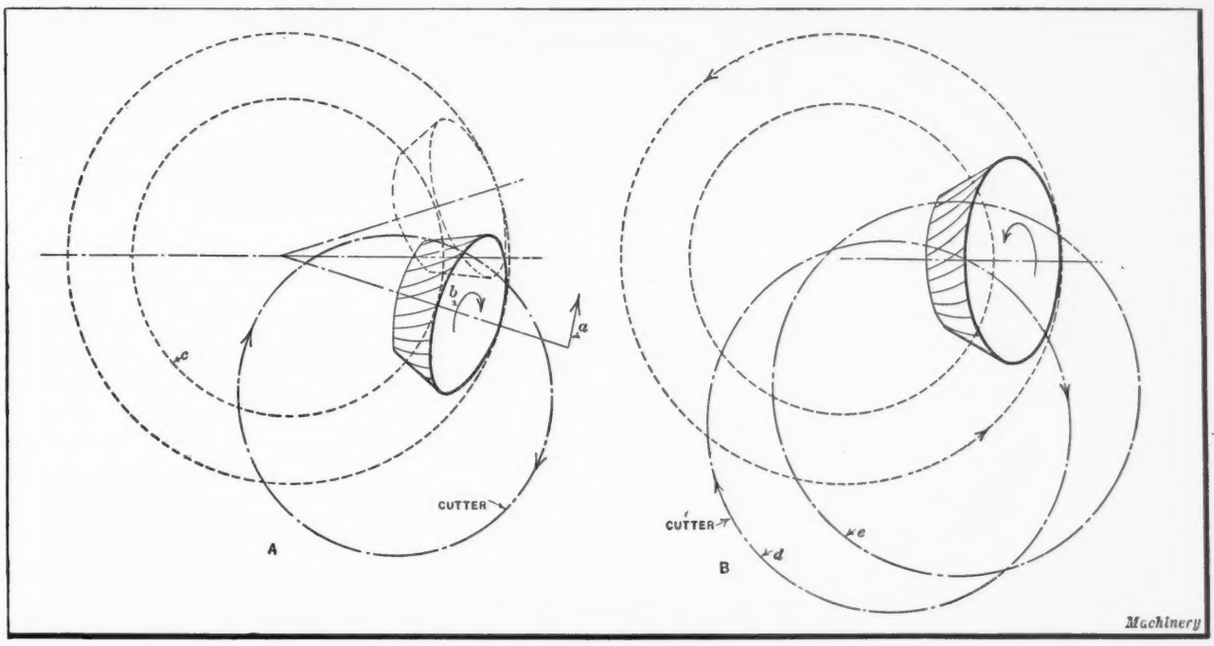


Fig. 8. (A) Movements when All the Generating Motion is applied to the Work; (B) Generating Motions applied to Both Gear and Cutter

Adjustment of Work- and Cutter-spindles

The work-spindle is mounted on a segment-shaped projection *B* (Fig. 7), which is integral with cradle *C*. This cradle receives an oscillating motion through a connecting link and crank mechanism located inside the frame of the machine. The work-spindle is adjusted relative to part *B* in accordance with the angle of the gear or pinion to be cut. The slide *D* (Fig. 6) carrying the cutter-spindle is also adjusted vertically, and the entire cutter-head is moved horizontally for locating the cutter in the proper position relative to the gear blank, as determined by the spiral angle of the teeth and the hand of the spiral. While the same cutter may be used for both gears and pinions, its vertical position relative to the center of the work must be reversed. For instance, if the center of the cutter is below the gear center, it must be above the center when cutting the mating pinion, because the teeth of the gear and pinion are of opposite hand.

The Operating Mechanism

Two motors are used to drive this machine. One motor *E* drives the cutter-spindle, and the other revolves the feed-cam for the cutter-spindle head and also the crank mechanism that oscillates the cradle *C* (Fig. 7) carrying the work-spindle. The axis of this cradle coincides with the axis of the crown gear segment *F*. Meshing with this crown gear segment is another master gear segment *G* (Fig. 6) connecting with the work-spindle sleeve; consequently, when cradle *C* is turned in its bearing, the master gear rolls on the crown gear and causes the work-spindle carrying the gear blank to turn about its axis as the gear itself moves to the position indicated by the full and dotted lines in diagram *A*, Fig. 8. This motion, relative to the cutter, is the same as when both gear blank and cutter receive the generating motions.

Cycle of Movements of Machine

When the machine is cutting a gear, the movements are as follows: The cutter is moved in to the cutting position by a cam, and it begins to cut as the work-spindle approaches the bottom of the rolling movement. A tooth space is finished on both sides as the gear rolls upward. Just before the upward movement is completed, the cutter begins to withdraw; then as the downward or backward motion takes place, and after the cutter is clear of the work, the latter indexes to bring the next successive tooth space around to the cutting position. The cutter is then gradually advanced into the gear blank during the remainder of the downward rolling movement, but it does not reach the full depth position until just after the beginning of the upward movement. This cycle of operations is controlled by what is known as a "completing cam."

The indexing movement is derived entirely from the generating motion by means of a mechanism located at the outer end of the work-spindle. The dividing plate *A* (Fig. 7) which forms part of this mechanism contains as many notches as there are teeth in the gear to be cut.

Cutting Both Gear and Pinion by Spread-blade Method

In view of the fact that both sides of a tooth space are generated at the same time when the spread-blade method is employed, it is apparent that the tooth does not have the same converging form that is obtained when one side is cut at a time, as is often done on the larger machines. With the former method, the tooth space has a uniform width at the bottom. Teeth generated in this way, however, operate satisfactorily, assuming that the pinion is cut to suit. The pinion, as well as the gear, may be cut by the spread-

blade method, and this is done in the case of small spiral bevel gearing. When this duplex spread-blade method is employed, the cutter is sunk somewhat deeper at the large end or shallower at the small end on the gear or pinion, or on both, to obtain a space of the required width. In cutting gears by this method (cutting deep at the large end or shallow at the small end), it is customary to alter the face angles to suit the new root angles so as to maintain the standard amount of clearance. This method cannot be applied satisfactorily to gears for automobile drives, because either excessive under-cut or an excessive stub tooth form results from the modified depth. In the case of larger gearing, if both sides of a tooth space are finished simultaneously, it is common practice to take two cuts when cutting the mating pinions.

Rates of Production for Spiral Bevel Gears

Production rates on spiral bevel gear generators are decidedly affected by the method of cutting the teeth. For instance, when the spread-blade method is employed, the time is about one-half that required when finishing one side at a time and indexing around twice. Pinions also require more time per tooth than gears, because the generating motion necessary for a pinion tooth extends over a larger arc. When using a 4-inch generator, the time required for cutting cast-iron gears having 28 teeth of 18 diametral pitch, was 10 seconds per tooth; the floor to floor time was 5 minutes 10 seconds. The gears cut on this small machine are finished direct from the solid blank, as previously explained. The production rate on the 8-inch machine when cutting low-carbon nickel-steel gears with diametral pitches up to 4, varies from 10 to 25 seconds per tooth for the gear and is somewhat longer for the pinion. This applies to the spread-blade method. For example, the time when cutting 3½ per cent nickel-steel gears of 6 diametral pitch was 23 seconds per tooth by the spread-blade method, or 23 seconds per side when indexing around twice. When using the 15-inch generator for cutting nickel-steel gears of 4 diametral pitch and smaller, the time per tooth ordinarily varies from 20 to 30 seconds by the spread-blade method, and from 40 to 60 seconds when finishing the sides separately. The time for cutting pinions is about 50 to 70 seconds per tooth. The allowance for changing blanks, etc., varies from about 3 to 5 minutes per gear.

* * *

DEMAND FOR MACHINE TOOLS IN JAPAN

By S. NODA, President, Roku-Roku Shoten, Ltd., Tokyo, Japan

Manufacturers of machine tools in the United States will doubtless be interested in information relating to the kinds, types, and sizes of machine tools that are chiefly in demand in Japan. Of all classes, lathes sell in the greatest numbers. The majority are gap lathes of the English type, having swings from 10 to 20 inches, and beds from 4 to 8 feet long. The demand for American-type lathes without gap is only about 5 per cent that for gap lathes; such machines are built to some extent in Japan, but at rather high prices. Next in demand come larger gap lathes with swings from 24 to 40 inches and with beds from 12 to 20 feet long. Lathes of this type are mostly supplied by local builders. The prices average from 43 sen (21 cents) per pound for the smaller lathes, to 22 sen (11 cents) per pound for the larger sizes.

Next in demand come upright drilling machines of from 20- to 26-inch sizes, and smaller shapers of from 14- to 20-inch stroke. The shapers in greatest demand are the American type crank shaper with quick return. The domestic drilling machines average about 30 sen (15 cents) per pound and the shapers, 35 sen (17 cents). Large lathes, radial drilling machines, planers, and punching and shearing machines are also in demand, particularly among shipbuilders. Most of these machines are built by domestic manufacturers at average prices of from 25 to 35 sen (from 12 to 17 cents) per pound for the lathes and drilling machines, and from 22 to 28 sen (14 cents) per pound for the planers and punching and shearing machines.

Milling machines, gear-hobbing machines, and grinding machines are also in demand; these come chiefly from America. Plain milling machines and also some universal milling machines are built in Japan, but the domestic machines are higher in price than the American machine tools, and they are bought principally by the government. Twist drill grinders, cutter grinders, and other simple types of grinding machines are built in Japan at reasonable prices.

The state railways and other government shops and some of the big electrical works are the principal buyers of high-class machine tools, and most of their orders go to America. For plants of this type, heavy-duty tools, such as all-geared-head lathes, heavy-duty drilling machines, planer-type milling machines, car-wheel lathes, and gang and radial drilling machines are in demand.

Turret lathes and automatic screw machines are also coming into more general use. The chief buyers for these types of machines are manufacturers of bicycles, clocks, telephones, and electrical appliances. Most of these machines come from America. Recently, some German machines have been offered at extremely low prices, but the supply will not last very long. These classes of machines are not built in Japan to any appreciable extent.

The Machine Shops of Japan

Small shops scattered all over the country contribute greatly to the demand for machine tools. These shops employ only from five to ten men each, and have, perhaps, from three to five machine tools. The state railways, the army and navy, street railway shops, textile mills, machine shops in connection with mines, and contractors for harbor and road work come next on the list as important buyers. A considerable amount of equipment is required for the government aviation factories. The state railways and the other government and private shops of larger size are the chief buyers of American and European machine tools.

Aside from machine tools, Japan buys large quantities of mining machinery and railway and highway construction machinery, cranes, hauling engines and conveyors, sugar machinery, and steam and water turbines. The machinery for the chemical industry is chiefly bought from continental Europe. Textile machinery is imported chiefly from England. Steam and water turbines, and steam engines of the larger sizes, are chiefly imported, but are also made to quite some extent in Japan. This is also true of Diesel engines and other internal combustion engines.

The things that count in favor of imported machine tools and that the manufacturer in the United States must consider if he wishes to obtain and hold Japanese trade are accuracy and care in workmanship, making for precision; high-duty capacity; moderate price; good packing; and reasonable deliveries.

In the shipbuilding industry, where heavy machine tools are required, British tools have been bought to a large extent because of their rigidity. The British prices are also less on this class of machines than American. In some instances, certain types of British lathes are very much liked, but a study of the matter will show that some of these lathes are really built in accordance with American practice, and to some extent have been patterned after American designs. Generally speaking, both American and British machine tools find a market in Japan when they are of good quality and offered at a reasonable price.

* * *

Since the armistice, the building of railroad equipment has gone on at a very rapid pace in Germany with the result that today the 150,000 freight cars and the 5000 locomotives delivered to France by Germany in the latter part of 1918 and the early part of 1919 have already been replaced by new equipment.

Selection and Use of Babbitt Metal

By L. D. ALLEN, General Manager, L. D. Allen Metal Works, Chicago, Ill.

As stated in the article on babbitt metal published in October MACHINERY, the selection of the materials and the method of combining them are important factors in producing the required degrees of hardness and toughness in babbitt metals. In addition, babbitt manufacturers who are anxious to produce a high quality of bearing metals should refine the constituent metals to a high degree of purity and take great care to alloy them by methods that have been scientifically determined to give the best results. Bearing metals so produced will run cooler and have a longer life as bearing liners than those produced without the necessary care or adequate technical knowledge of bearing requirements.

There is more to the making of a good bearing metal than simply mixing or alloying certain percentages of constituent metals. The constituents may be well mixed, but the quality and permanency of the mixture are determined by definite laws. An alloy that may be perfect at a high temperature partly segregates at low temperatures, while others remain perfect alloys at any temperature. It is at this point in the procedure of producing a good bearing metal that so-called "private" or secret methods are employed, certain fluxes being used in combining the ingredients. The use of these fluxes is not apparent in analyzing the resulting alloy, but the employment of these processes involves considerable extra cost and accounts for the higher price of the best bearing metals. Aluminum, bismuth, arsenic, zinc, iron, nickel, cadmium, sodium, barium, strontium, and calcium are among the elements that are used at this stage of the manufacturing process. These elements are employed more especially by manufacturers of special brands, catering to a special industrial demand, where the quantities required are not large; for that reason, industrial concerns having unusual requirements are more inclined to observe and appreciate the better working value of these special bearing metals, and are willing to pay the necessarily higher price to obtain them.

In this article the author, who has specialized on bearing metals for many years, explains why there are such wide variations in different brands of bearing metals, and points out that there is more to the making of a good bearing metal than simply mixing or alloying certain percentages of constituent metals. He refers to the danger of selecting a bearing metal by analysis alone, and gives practical advice on the melting and pouring of babbitt metal for bearing liners. He also outlines the causes of shrinkage of babbitt metal when cast, and emphasizes the importance of pouring and casting the metal at low temperature.

Manufacturers of machinery in general, because of price competition, are inclined to economize in their purchases at every point where the cheapness of the material used will not directly affect the reputation of the product. Special care is given by their engineers to the selection of the steel, iron, brass, and other metals that have to do directly with the strength and stability of the machine; but when it comes to such items as bearing metals, the machine builder seems to believe that if the bearing burns out, the buyer of the machine can easily obtain babbitt from a local hardware store, a mill supply house, or a babbitt manufacturer, and rebabbitt the bearing himself, without any appreciable influence on the merits of the machine. This point of view, however, is a mistaken one, because a machine is no better in uninterrupted production than the endurance and service quality of its bearing.

Manufacturers of machinery should realize that the best babbitt for their requirements that expert babbitt manufacturers can produce is the most economical, regardless of price. In some cases it may be a lead-based babbitt, in others a tin-based babbitt. The selection of the best babbitt requires a practical knowledge of bearing conditions and of the properties of bearing alloys.

The Use of Virgin Metal

Very often large babbitt users who order according to their own formulas or specifications request that "virgin" metal be used. Many metallurgists claim that it makes no difference whether virgin metal or older metal is used, so long as the metal is pure, that is, free from dissolved oxides or oxides in a mechanical mixture with the metal. It is the oxides and similar impurities that impair repeatedly overheated or remelted metals. Some authorities claim that the dross of tin, lead, and antimony products—when free from iron, aluminum, zinc, and arsenic—smelted in an adequate reducing furnace at about 2500 degrees F., will, with proper additions, produce alloys that are superior to the same alloys made from virgin metals, because the alloying is better than when virgin metal is used exclusively. The author's experience, however, leads him to believe that chemically pure well-balanced alloys made of virgin metal produce the best and strongest babbitt metals made, and that they also possess higher anti-frictional properties than babbitt metals produced in any other way.

A babbitt **should not** be selected by analysis, as there are many points to be taken into account in the making of the metal that have to do with its physical properties, but that evade the chemist; nor should any one babbitt be selected for all bearing requirements. Metals high in lead have the best anti-frictional properties when properly produced; but metals high in tin and copper are desirable when toughness combined with hardness is required to meet unusually severe bearing conditions. Price and analysis are both dangerous factors to rely on in the selection of a babbitt. The size of the bearing, the thickness of the lining, and the speed and load conditions should influence the choice; and for that reason properly made lead-based babbitts will often, because of their better anti-frictional properties, give superior service to that obtained with the more expensive tin-based metals.

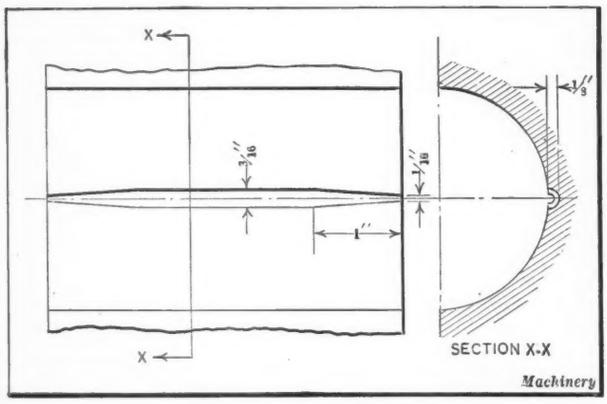
The safest course for the manufacturer who wishes to secure the best wearing qualities is to obtain his babbitt from a maker who is known to be thoroughly experienced in analyzing bearing requirements. His experience enables the maker of babbitt to specify just what metals or combinations of metals will possess the best endurance and anti-frictional properties in each case.

Melting Babbitt Metal for Bearing Liners

The first essential, after selecting the right metal, is to have a clean pot and ladle, so that some other metal which may have been previously used will not get mixed with and contaminate the babbitt about to be melted and applied. A high-grade lead-based anti-friction alloy should be heated

to a point that will give a pine stick a very brown color. It should then be thoroughly stirred, the scum which forms on top removed, and the metal at once poured into the bearing. The liner or casting should be completed at one pouring. The bearing should be poured as near as is convenient to the pot containing the metal, because carrying metal a long distance in a ladle is likely to cause it to chill and pour sluggishly. Overheating a babbitt adds to its brittleness; pouring it too cold causes seams to form in the lining. It is always advisable to have a third more metal in the ladle than is required for pouring.

It is desirable to have the bearing warm or fairly hot, as pouring hot metal against a cold backing will cause the metal to shrink slightly away from the backing. The backing and mandrel against which the metal is poured should be clean and free from grease and moisture. Clay or asbestos wool dipped in heavy oil is used to close up the ends of the bearing so as to retain the metal while it hardens and seats. The metal should be poured slowly at first, the volume being gradually increased. This method usually expels the air from the bottom. The gate or pouring hole should be large enough so that the metal can be



Groove cut in a Bearing to form a Grit Trap

admitted in sufficient volume to be forced quickly to the farthest part of the bearing before it chills against the cold surface.

The liner or newly poured bearing can be made denser and more durable by cooling quickly. This can be done by applying cold water to the outer shell or surface. Care must be taken, however, to see that no moisture or water gets into the molten metal, as if it does, a slight explosion or spatter of the metal will result.

Babbitt metal must not be allowed to stand long in the kettle or ladle before pouring, because of the specific gravity of the different ingredients; lead, being the heaviest, gradually works its way to the bottom, antimony comes next, and tin, being lighter, works to the top. This is why the metal should be stirred thoroughly before pouring so that it will not segregate or separate.

It is important that the mandrel or shaft be centered so that the liner will be of the same thickness all the way around, and also at each end. In that way a perfect alignment is afforded the shaft when in operation. When the shaft is out of alignment, only certain parts of it are in contact with the bearing surface, and the result is the rapid destruction of the bearing. Smoking or chalking a mandrel produces a smooth surface. Liners should always contain oil-grooves so as to distribute the oil thoroughly over the bearing surface.

If a shaft is very badly cut or scored, a lead-based babbitt, being softer and more plastic than one high in tin and copper, will fill in these scored or cut parts, thus producing a smooth shaft surface. In using a lead-based babbitt, it is not always necessary to scrape or smooth the surface of the liner after it is poured, as it quickly wears to a smooth surface as soon as the shaft is put in motion. When a bearing heats a little on being started, it is usually because it is wearing to a smooth surface. In such cases if the machine is stopped for a few moments and then started again, the bearing will run cool because a smooth surface has been formed.

Grooves for Catching Grit and Dust

In plants where bearings wear rapidly because of the abrasive action of grit and dust, greater durability can be obtained by cutting a groove, where it is practical to do so, to serve as a grit trap. This groove should be cut lengthwise of the bearing, as shown in the illustration, and as close to the gravity center of the bottom half of the bearing as possible. By "gravity center" of the bearing is meant that part of the surface of the bearing liner on or against which the shaft pressure is the greatest. This pressure is governed by the pull and direction of the belt or gear drive. If the point where the load carried on a particular bearing coincides with the gravity center, that is, if the pull and direction of the belt or gear drive is directly downward, then the groove should be placed an inch or more back of the gravity center.

The groove should run nearly the entire length of the bearing, and should be cut to a depth of about ⅛ inch, depending somewhat upon the thickness of the liner. If too deep, it might cause the liner to crack. At each end, the groove is cut shallower, as shown in the illustration, from a point about one inch from the end of a liner, so that when the groove is filled with grit, the grit will be expelled through the aperture at the end of the groove by the shaft pressure. The edges of the groove should always be rounded off. Care should be taken to construct this groove so as to prevent waste of oil, as otherwise an excess of oil will pass out of the bearing. The outer opening of the groove should be very slight, say 1/16 inch. Grooves like this can, of course, be cut only in horizontal bearings.

Shrinkage of Bearings

Trouble frequently results from shrinkage and cracking of babbitt metals when cast. If a high-grade tin-based genuine babbitt metal is poured when overheated, or if it is poured against an overheated mandrel, or into a container that has been overheated, minute cracks will form in the liner, and these cracks, under shaft vibration and pressure, gradually increase in size, allowing the oil to seep through and work its way in between the liner and the backing. The result of this is frequently a loose bearing; and the heat conductivity of the oil, being practically nil, compared with that of the metal, prevents the friction heat from being conducted through the liner into the backing so that it may escape. Consequently, the bearing retains the heat to the point of fusion and destruction of the liner. If a moderate-priced lead-based metal is cast when overheated, the result will be that the metal itself will be made more brittle and coarser in grain, and by reason of this it will crack, break, and crumble more readily.

The difference in expansion and contraction between the babbitt metal and iron and steel causes an unequal strain on the solidifying metal when it contracts in cooling. This shrinkage is sometimes so great as to cause loose liners, which have only limited service and durability. In order to offset these common and cardinal bearing troubles, the principle of casting the metal at the lowest temperature at which it is fluid enough to "flow" the casting at one pouring, and not against a backing or mandrel or into a container which has been overheated, should be observed.

Value of Casting the Metal at a Low Temperature

All bearing metals are alike in that the hotter they are, when cast, the more open and crystalline will be the grain that comprises the structure of the metal. The lower the temperature of the metal when cast, the more dense and solid will be its structure, and the longer wear will it give under equal conditions. For bearings subject to extreme

pressure, it is desirable, where convenient to do so, to immerse the casting slowly in water from the bottom upward, immediately after the metal has solidified. This will further increase the density of the structure of the liner. The casting should not be dumped into the water, but taken with tongs and slowly immersed, beginning at the part of the casting or liner farthest from the point of the gate or opening into which the metal was poured.

* * *

SAVING MATERIAL AT THE EXPENSE OF LABOR

By ROBERT GRIMSHAW

Sometimes materials can be saved by the expenditure of a small amount of labor. Again, labor can be saved at the expense of a small amount of material. Judgment and cost calculations are required to determine if a dollar's worth of material can be saved by the outlay of less than 100 cents worth of labor; and, conversely, whether 100 cents worth of labor might be saved by the use of less than a dollar's worth of material. In both instances, of course, it must be understood that the procedure must not cause costly delays, or deterioration in the quality of the product. The problem must be carefully figured; because snap judgment in a case of this kind is usually dangerous. It is not always so easy to figure whether it is cheaper to save material or to save labor, as it might seem to be. While most establishments have cost clerks who can tell quite accurately how much an article that has been made has cost for each of the three factors—material, labor, and overhead—few have men capable of determining beforehand with any degree of accuracy how much it will cost to do a certain job by any one of two or more methods.

Material can be saved at the expense of labor costs in two ways: (1) By using the same class of labor that would ordinarily be used, but allowing more time for the operation, the object being in this way to reduce the amount of waste material on the one hand, and spoiled pieces on the other; (2) by using a higher and more expensive grade of labor, thereby accomplishing the same ends. In either case, it is necessary to determine whether the saving in material and that due to the absence of spoiled pieces exceeds the additional labor cost.

A few examples may illustrate when and when not material should be saved at the expense of labor. One example may be seen in the foundry, when an effort is made to save materials at the expense of labor by offering a bonus for decreased percentages of defective castings. To a certain extent this may effect an actual saving; sometimes, however, it does not. The perfect pieces will cost more per unit for labor, but metal, fuel, and supplies are saved. The more complicated the castings, the lighter they are, and the more expensive the metal poured—reckoning its cost in the ladle, which is its true cost from the accounting point of view—the greater the opportunity for saving in this way. The simpler the casting and the cheaper the metal poured, the less likely it is that an actual saving will be accomplished by spending more for labor and trying to get all perfect castings.

In cutting patterns out of sheet metal, it may be possible, by taking a longer time in laying out the patterns, to use the metal more economically, but the cost of the saved metal may not equal that of the additional time spent in laying out this stock economically. Judgment and understanding of both labor and material costs are necessary to determine the best procedure.

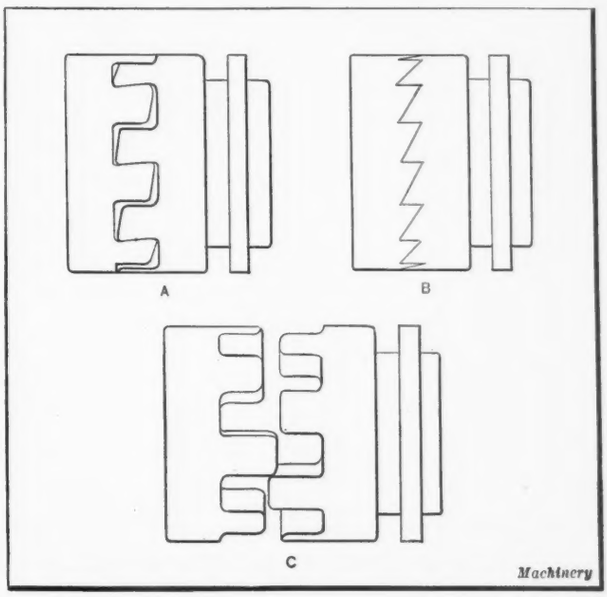
A story is told of a tool-room where a certain appliance that costs $2 on the market was repaired at various intervals, a first-class toolmaker spending some three hours in making the repairs. Labor was foolishly spent to save a device that could have been bought at a lower price than the cost of repairing.

TOOTHED-CLUTCH DESIGNS

By C. M. LINLEY

A good design of toothed clutch for drives in which the rotation is always in one direction is shown in the illustration at *A*. The engaging surface of the teeth on both members is under-cut slightly so as to facilitate full engagement after the teeth have partly entered. This construction also prevents them from being separated when the load is on. It is unwise to use clutches of the type illustrated at *B* in drives where there is any possibility of a reversal in the direction of rotation, as reversal would cause the members to be forced apart, and might strain the mechanism that controls the clutch.

Many toothed clutches are operated in both directions, and in such cases a slope on the ends of the teeth is undesirable; furthermore, under-cutting of the engaging faces to any marked degree weakens the roots of the teeth. But it is sometimes difficult to cause square-cut teeth to engage unless the driving member is brought almost to a stand-



(A) Toothed Clutch with Sloping Contact Faces; (B) Sawtoothed Clutch; (C) Clutch with One Long Tooth

still. This is due to the difficulty of having all the teeth enter at one time. The clutch shown at *C* was designed to overcome this difficulty. One of the teeth in both members is somewhat longer than the others. These long teeth will engage at a higher speed than is possible when the teeth are uniform in length, and, once engaged, the long teeth lead the others into place. Sometimes more than one long tooth is provided on each member.

* * *

VALUE OF MACHINE TOOLS AND METAL-WORKING MACHINERY EXPORTED TO BELGIUM, 1912-1921

Year*	Lathes	Sharpening and Grinding Machines	Other Machine Tools	Total of Machine Tools	All Other Metal-working Machinery	Total of Machine Tools and Metal-working Machinery
1912	.....	.....	.....	.....	.....	$646,541
1913	.....	.....	.....	.....	.....	786,679
1914	.....	.....	.....	.....	.....	552,531
1915	.....	.....	.....	.....	.....	35,416
1916	.....	.....	.....	.....	.....	.....
1917	.....	.....	.....	.....	.....	.....
1918	.....	.....	.....	.....	.....	.....
1919	$1,222,885	$461,012	$226,254	$1,910,151	$1,972,012	3,882,163
1920	531,755	194,210	469,977	1,195,942	724,230	1,920,172
1921	236,996	37,652	125,003	399,651	262,476	662,127

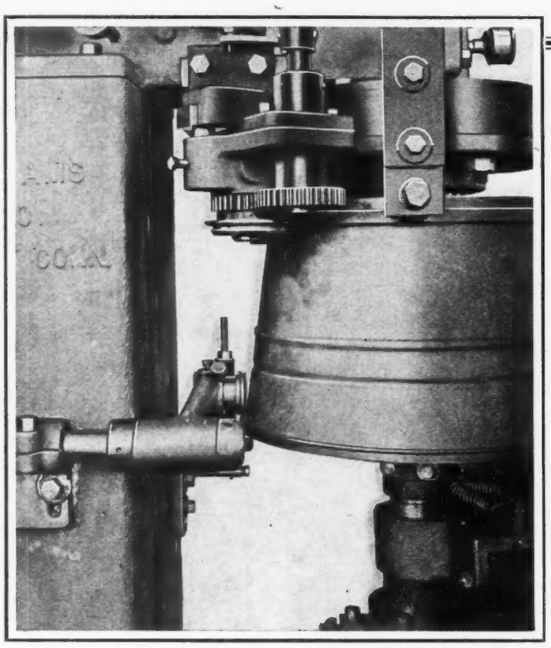
Machinery

*Amounts given are for fiscal years, up to and including 1918, and for calendar years thereafter. The Department of Commerce statistics did not give machine tool exports separately previous to 1918.

Manufacturing Pails and Tubs

Semi-automatic Machines Designed for Producing Large Sheet-metal Containers

By PAUL H. LANGE, Chief Engineer, The Max Ams Machine Co., Bridgeport, Conn.



SEVERAL operations are eliminated and labor is saved in the manufacture of large sheet-metal containers, such as pails and tubs, through the use of a number of machines that have been designed and built by the Max Ams Machine Co., Bridgeport, Conn., especially for work of this kind. The machines are intended for pails and tubs made from Nos. 28 to 26 gage galvanized or black sheet iron. The bodies are made in two or three sections and the bottoms are attached by a double seam. The tubs vary in diameter at the bottom from 14 to 21 inches, and at the top from 18 to 24 inches. Their height ranges from 9 to 11 inches. The pails vary in diameter at the bottom from 7½ to 10 inches, and at the top from 9 to 14 inches, the height ranging from 8½ to 11 inches.

Machine for Edging Both Ends of the Sheets

After the body sections are blanked in a punch press they are delivered to the duplex edging machine illustrated in Fig. 3, which simultaneously forms the ends of the body sections as shown at *A*, Fig. 6. The blanks are placed on the table of the machine and conveyed automatically to the edging station by means of feeding fingers *A*, Fig. 3, which are attached to a cross-bar. The latter is fastened to a slide reciprocated by power transmitted to it from crank disk *B* at the left-hand end of the machine, through connecting-rod *C*, rocker arms *D* and *E*, the shaft on which the rocker arms are mounted, and the link that connects arm *E* to the slide.

The positions of the edging heads *F* and *G* are adjustable by means of a screw actuated through handwheel *H*. This provision permits the handling of blanks of different widths. The heads can also be set at different angles to suit the taper of the blank ends, graduations being provided to facilitate this adjustment. The ends of the blank are bent back as the feeding fingers push the blank under plates attached to the front of the edging heads, and the work is automatically discharged at the completion of the operation. This machine edges, on an average, 30 blanks per minute. It weighs about 5000 pounds.

The next operations on the assembled tubs are wiring, beading and flanging as described in the following: The tub body sections are assembled in a horning press

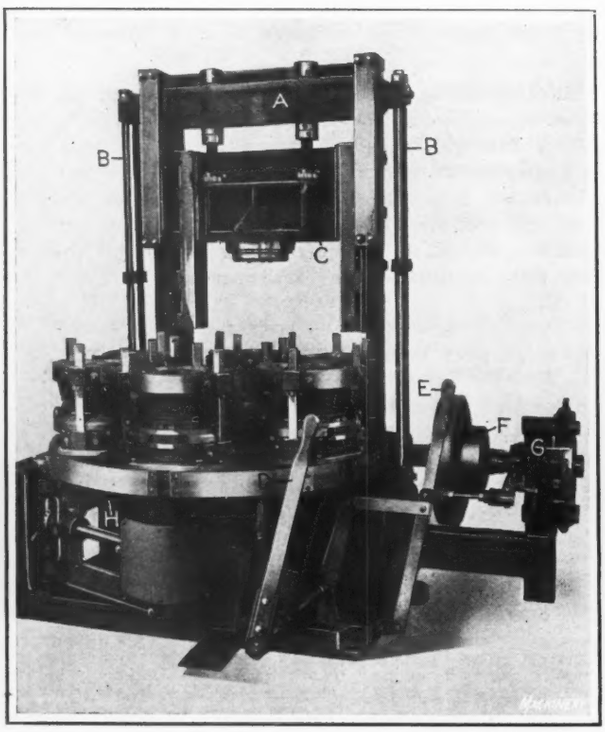


Fig. 1. Turret Press for Pail Manufacture, which is equipped with Six Dies and One Punch

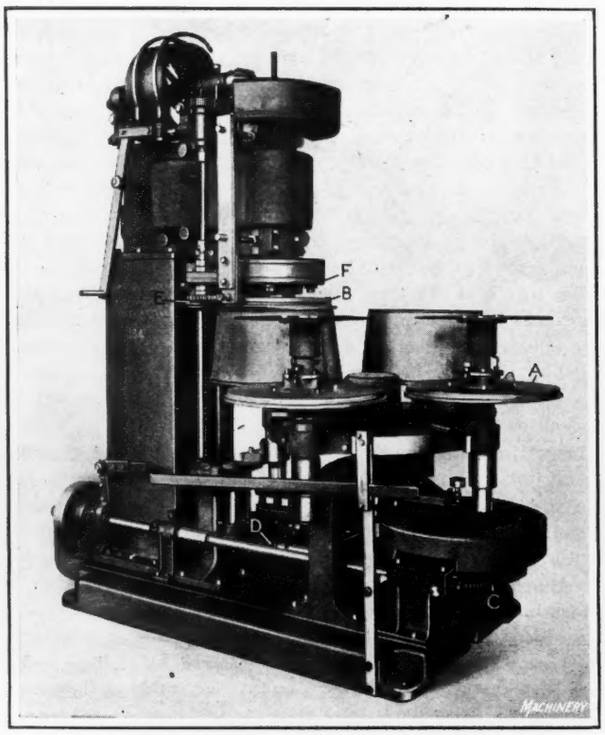


Fig. 2. Another Turret Machine, used for double-seaming the Bottom to the Body

and then delivered to a turret press of the same general design as the machine shown in Fig. 1, except that it is larger and equipped with four dies instead of six. The machine is automatic except for the loading and unloading of the work. The four dies are mounted on a turret plate, which successively brings the dies into position beneath the punch. The appearance of the work after this operation is shown at *B*, in the illustration Fig. 6, the top edge being wired, the reinforcing beads formed, and the bottom flanged. A view of the punch and one of the dies used for this operation is shown in Fig. 7, this illustration being reproduced from a photograph taken of a machine equipped with only one die instead of with four dies, as described.

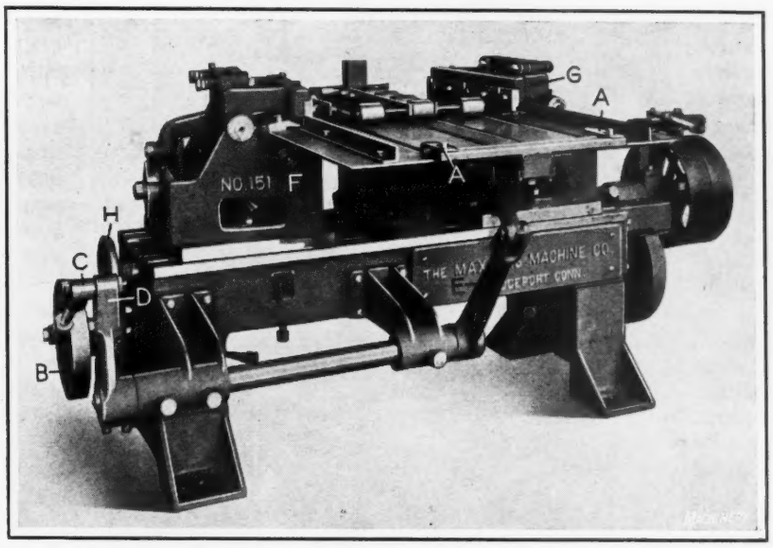


Fig. 3. Duplex Machine for edging the Ends of Tub Blanks as shown at A, Fig. 6

The turret press has a built-up frame consisting of a bed, uprights, and an arch. The cross-head *A*, Fig. 1, is driven from the main driving shaft through the medium of twin crank gears and the upright connecting-rods *B*. Slide *C* is connected to the cross-head by two screws which permit the slide to be adjusted vertically to accommodate dies of different heights. The machine is double back-geared and driven through friction clutch *F*. The machine can be stopped and started at any point of the stroke by means of hand-levers *D* and *E*, which control the friction clutch and brake *G*. In addition, the foot-treadle may be employed to disengage the clutch if the operator is unable to finish placing the work in any of the dies by the time it advances to the punch.

The turret plate is driven by means of a swinging cam arm to which spur gear *H* is attached. A feed pawl on this arm successively comes into engagement with four equally spaced dogs on the inside of the turret plate rim. A pinion driven from the rear driving shaft through a train of bevel gears engages the cam gear and imparts a rotary movement to the turret plate. With this arrangement the dies are brought successively into the correct position beneath the punch. The pauses between the intermittent movements of the turret plate allow the operator sufficient time to remove a finished piece from the die and insert a new piece without stopping the machine. As the handling of the work is done while the dies are out of the path of the punch, the operator is not exposed to danger.

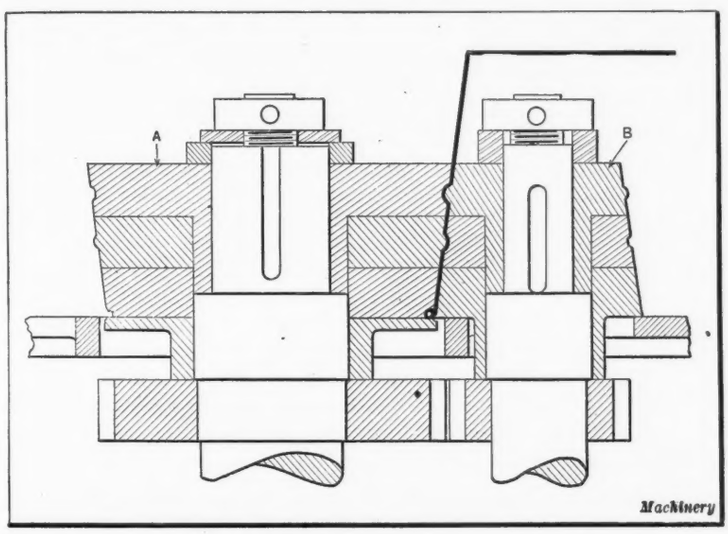


Fig. 4. Construction of Beading Rollers on the Rotary Beading Machine illustrated in Fig. 8

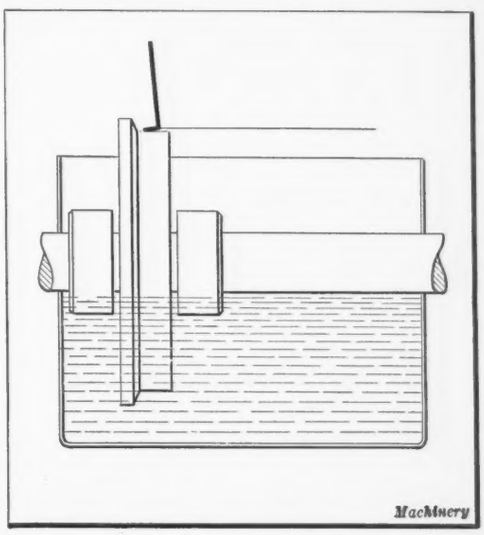


Fig. 5. Diagram of Compound Tanks on Machine shown in Fig. 9

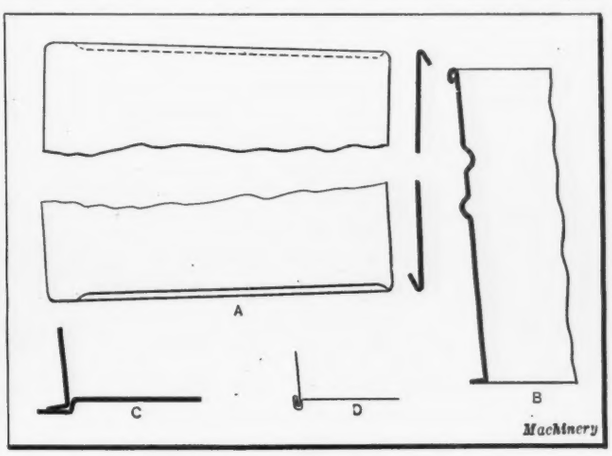


Fig. 6. Diagrams showing Different Stages in the Production of Pails and Tubs

The turret spacing mechanism has a safety device which automatically disengages the clutch and stops the machine if, due to an accident, the punch and a die should not register correctly. The machine employed for this operation has an average production of ten tubs per minute. It weighs about 12½ tons. As previously mentioned, the machine in Fig. 1 is actually equipped for operations on pails, wiring them at the top and flanging them at the

bottom, the outline being as shown at *B*, Fig. 6, with the exception of the reinforcing beads. This press produces fifteen pails per minute, and weighs about 7½ tons.

Rotary Beading Machine

In cases where it is preferable to produce the reinforcing beads on a tub in a separate operation, the rotary beading machine shown in Fig. 8 is employed. This machine has one large central roller *A* and four smaller rollers *B*. The smaller rollers are mounted on a continuously revolving turret *C* and move in a circle about the central roller. The latter is driven by means of bevel gears and a double train of spur gears, the spur gears being located on the outside of the housing. The turret is driven through the large spur gear *D*, its pinion, and a pair of spiral gears, which connect to the main drive. Rollers *B* are also rotated about their own axes by being driven from the central roller shaft through spur gears as illustrated in Fig. 4.

The upper section of all the rollers is keyed to its shaft while the other two sections are idler members. Rollers *B* are slightly advanced toward and withdrawn from the central roller as the turret revolves, due to the action of toggles *E*, Fig. 8, which are controlled by cam *F*. The operator places the work over the small rollers when they have been withdrawn from the central roller, and removes it when the beading operation is completed. This machine produces ten tubs per minute. It weighs 7000 pounds.

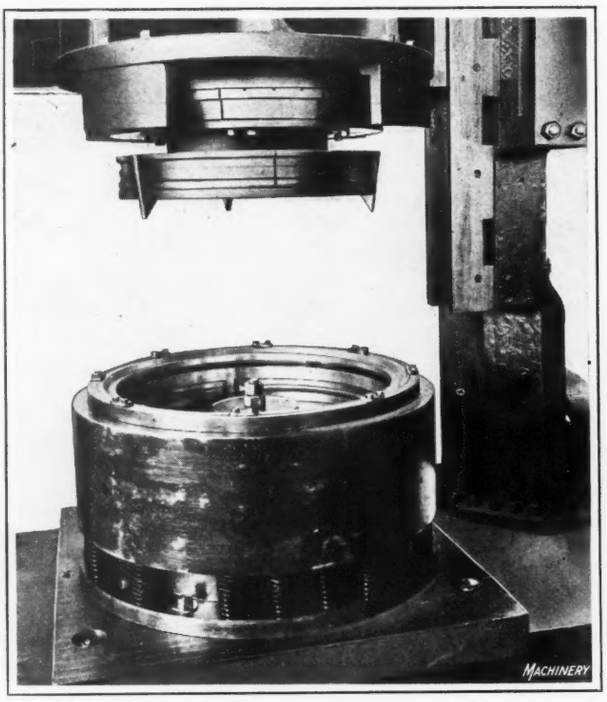


Fig. 7. Punch and One of the Dies employed for wiring, beading and flanging the Tub Body

Assembling the Bottom to the Body

Double-seaming the bottom to the body produces a watertight seam, but even better and more reliable results are obtained if the body flange is first covered with a cementing compound. A machine intended for coating the body flange with this compound is illustrated in Fig. 9. It has three containers for the compound, each container having a continuously revolving wheel upon which the work is supported. The wheels are partly submerged in the compound and as they rotate, they deposit it on the flange of the body. The wheels are driven from the horizontal driving shaft through bevel gearing. Fig. 5 illustrates diagrammatically a sectional view through a container. Each of these is heated either by gas or electricity to keep the compound fluid.

The bottom is next double seamed to the tub body on the machine shown in Fig. 2. The work is first prepared as shown at *C*, Fig. 6, and is then seamed as shown at *D*. The machine in Fig. 2 is automatic except for the loading and unloading of the work. It has a turret to which are attached four work-holding fixtures *A*. The intermittent rotation of the turret is obtained through a Geneva mechanism that brings the work-holders successively into alignment with chuck *B*. The chuck revolves continuously, being driven from the horizontal pulley shaft at the top of the machine through bevel gearing.

The Geneva mechanism is driven through worm-wheel *C* and a worm which is keyed to the horizontal shaft at the front of the machine. This shaft, in turn, is driven by a belt from the main driving shaft. The work-holders are raised at the seaming station by the action of cam *D*, and thus clamp the work between the holders and the chuck. When in this position the work-holder and the work are also revolved through the rotation of the chuck. As the

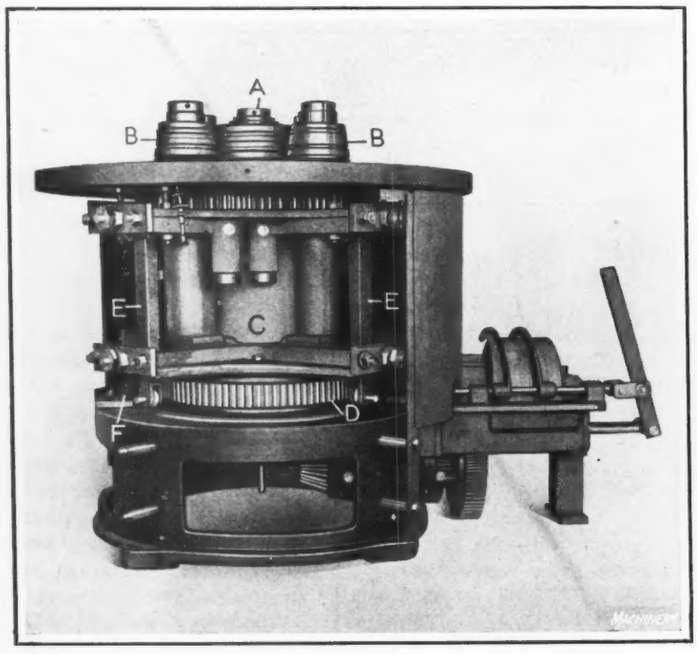


Fig. 8. Machine employed when it is Desirable to produce the Reinforcing Beads in a Separate Operation

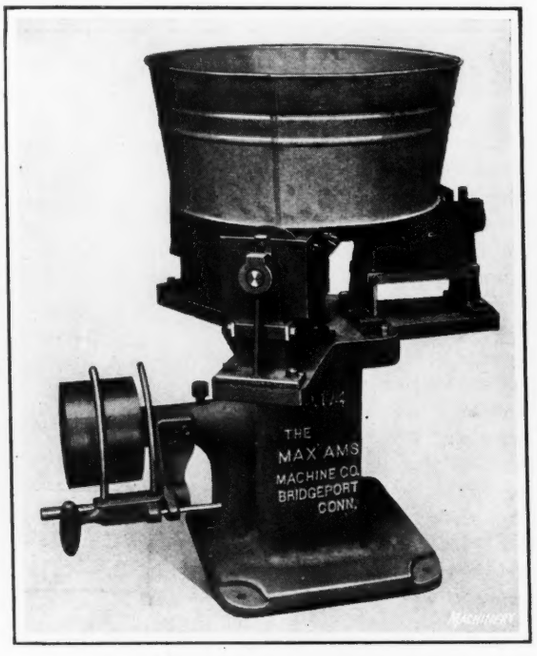


Fig. 9. Depositing the Cementing Compound on the Body Flange

turret carries the work-holder away from the seaming position it is lowered.

Two seaming rollers are required for the operation. The first roller *E* is driven through gears and a universal joint connected to the main drive, while the second roller, at the opposite side of the machine, is not driven positively, but revolved by coming in contact with the work. The two rollers are mounted on an oscillating member *F* which is operated through the medium of an eccentric to bring the rollers alternately in contact with the work. An electromagnetic clamping device holds the bottoms in place while they are being brought to the seaming station. The turret, work-holder, and roller mechanisms may be started and stopped readily by shifting the lever of a hand-operated friction clutch.

This machine can also be equipped with a smoothing roller attachment such as is shown in the heading illustration, the purpose of which is to finish the wired top edge of the tub simultaneously with the seaming operation. This attachment is fastened to the side of the machine column and its roller is in contact with the work as the work revolves about its own axis. The average production of this double-seamer is ten tubs per minute. It weighs approximately 6000 pounds. When it is used for seaming pails, the turret is equipped with eight work-holders in order to obtain a somewhat greater production. The machine then has an output of about fifteen pails per minute.

* * *

STARTING AN APPRENTICE SCHOOL

By WARREN ICHLER

Unfortunately, like most other developments that can demonstrate their value only indirectly and after a long period of trial and experiment, the apprentice school is regarded by too many executives as one of the "frills" of modern industrial development. This places both the apprentices and the instructors under the double handicap of poor surroundings and an unfavorable attitude on the part of shop executives. The writer, in various capacities of adviser and instructor, recently assisted in founding an apprentice school at a large mechanical plant in a city in the Middle West; the experience gained at this plant and through close observation and study of apprentice school work in various other plants has given him a good idea of the obstacles to be overcome and the mistakes most likely to be made in starting an apprentice school. Aside from the minor mistakes incident to all such ventures in their beginning, three major errors showed up prominently in the particular school mentioned. They are more general than local in their nature and scope, and hence are deserving of a short discussion so they may be avoided by those contemplating the founding of similar schools.

The first really serious obstacle to successful instruction work was found in the text-books selected. There is no doubt that the writers of these books honestly attempted to produce works that could be easily understood by the average boy of eighteen, but it was found that the subject matter of the various books had to be presented in much simpler language by means of informal lectures. This is not to be construed as a statement that all text-books are written in a style unfamiliar to the average apprentice. But many of them are difficult to understand, and for that reason great care should be taken in their selection.

An apprentice cannot readily bridge the gap between the concrete and the abstract, and in this respect is comparable to the average college student who demands practical demonstrations and a generous use of models to supplement the subject matter of his texts. This brings us logically to the matter of the selection and training of apprentice instructors as regards temperament, language, patience, etc., which, unfortunately, is the second point of criticism to be raised regarding the apprentice school in question. In an effort to secure the best instruction possible, certain young ambitious teachers from the high schools of a neighboring city were engaged to teach the purely theoretical work, practical instruction in the shop being cared for by mechanics assigned to that duty.

In theory, this plan would seem to be ideal, but in practice the results were far from satisfactory. However, no criticism attaches to the efforts of the teachers engaged from the city schools. It seemed impossible for them to effect an adjustment of their language and methods of instruction so that they would be entirely in sympathy with their classes. The work of these men as instructors in the city's high schools was remarkably good, and in an effort to find their trouble in dealing with apprentices, other instructors (toolmakers and machinists from the shop), were occasionally substituted for them in teaching theoretical work. Since these mechanics from the shop were uniformly successful in securing a better degree of cooperation from their classes and a better understanding of the matter discussed, than the teachers regularly engaged for this work, it is a fair inference that the methods of the high school teacher or even those of the grade school teacher, are not applicable in the apprentice school.

Unless high school teachers who have had the practical training that enables them to instruct from the shop man's viewpoint can be secured, it would be better to leave even the theoretical instruction in apprentice schools to mechanics from the shops, provided, of course, that men qualified for this work are available.

Possibly the failure of competent high school teachers to do really good work in apprentice schools can be traced to the facilities provided in the apprentice school. This is the third point criticised in the particular case cited. The rooms provided were such that all-year-round class work was impossible. Further than this, the accessories such as pencils, paper, drawing instruments, etc., had been provided on an "economy first" basis, which is obviously a mistake.

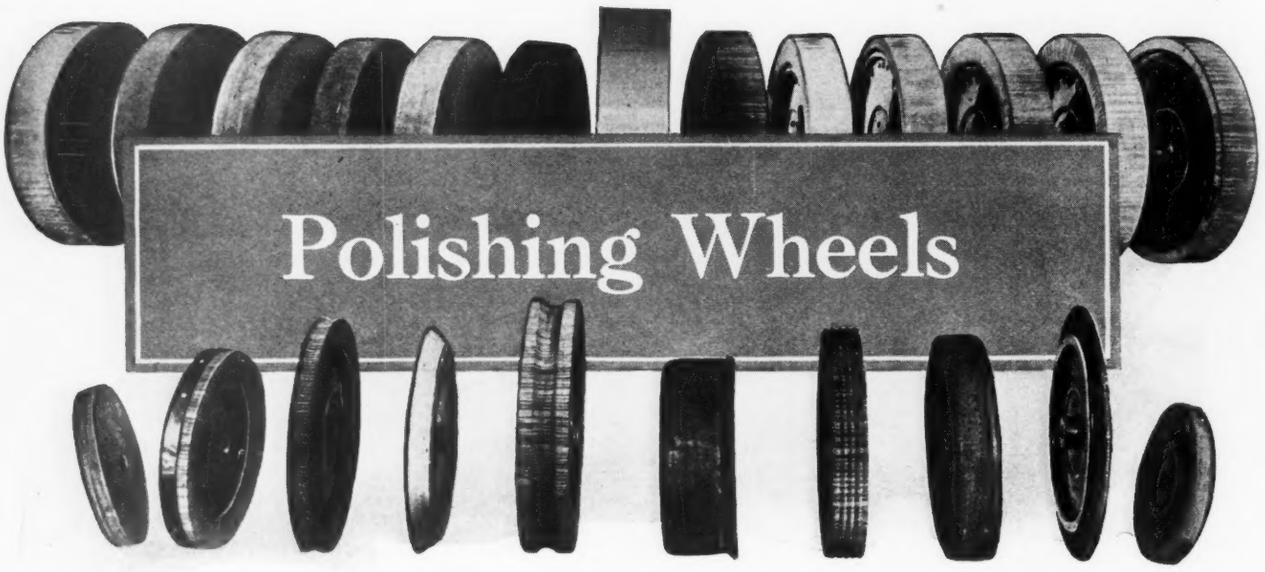
* * *

SMALL RACK-CUTTING MACHINE

Several interesting features are incorporated in a special rack-cutting machine employed in the plant of the Seneca Camera Mfg. Co., Rochester, N. Y. The machine is used to cut teeth of 0.0683 pitch in one side of brass rods, ⅛ inch square and 8 feet long. After the teeth are milled, the rods are cut off to lengths ranging from 4 to 6 inches as required. The most interesting feature of the machine is the high cutting speed employed, which is 1300 feet per minute. This may be considered more remarkable in view of the fact that the machine was developed and built about fourteen years ago when high speed steels had not been developed to their present-day state of efficiency.

The milling cutter is 1¼ inches in diameter and is driven by belt and 1 to 1 ratio gears at a speed of 4000 revolutions per minute. It is carried on a ram similar in design to that of a shaper, and the stock, which is supported in a tubular guide on each side of the machine, is ordinarily fed through the vise on each forward stroke and backward stroke of the ram. When the machine is set to cut both on the forward and backward strokes it requires about fifteen minutes to cut the teeth in an 8-foot rod. An electric bell located on the side of the machine indicates when a rod has been completed and more stock is required. If desired, the feed mechanism of the machine can be set so that on the return stroke the cutter will pass through the tooth space cut on the preceding stroke. When so arranged, the cutter will cut a tooth space only on the forward movement of the ram. Obviously a higher degree of accuracy is obtained when the machine is set to operate in this manner, as each tooth is cut under exactly the same conditions. As the chips fly with considerable force from the cutter, a hood is provided which deflects them downward into the box in front of the machine.

E. C. S.



Polishing Wheels

General Construction of Polishing Wheels Used for Metal Finishing—Characteristics of Polishing Abrasives

By BRADFORD H. DIVINE, President, Divine Bros., Utica, N. Y., and President of the Metal Finishers' Equipment Association

THE principal materials from which polishing wheels are made are wood, leather, canvas, cotton cloth, felt, paper, walrus or sea-horse hide, sheep-skin, impregnated rubber and canvas composition, and wool. The leather-covered wood wheel is very popular with polishers, although its disadvantages are numerous. It frequently gets out of balance and the leather facing, if not treated with great care, becomes loose and dangerous to the operator. It is the most common form of polishing wheel, due principally to its being cheap and easy to make.

Leather-covered Wood Wheels

A leather-covered wood wheel that will retain its balance and shape should be made from a wood that is not likely to change shape easily due to climatic conditions. Poplar and basswood are not suitable, although they have been used to some extent, because they are generally easily influenced by changes in temperature and humidity, resulting in warpage, shrinkage, and general distortion. They are very porous, so that they readily absorb moisture. Polishing wheels are operated in hot factory rooms where artificial heat is supplied in winter, and where they come in contact with moisture when the glue and abrasive are being soaked off in water. Hence, they are subjected to every influence that would cause them to change shape.

The best woods from the standpoint of stability under such conditions are black walnut, mahogany, and cherry; but their use for polishing wheels is commercially impracticable on account of their cost. The most suitable wood for general use is air-dried or kiln-dried white pine. It does not change its shape readily through atmospheric conditions and gives general all-around satisfaction.

The old style of leather-covered wood wheel consisted of a solid or laminated wood block with the leather facing strap glued in place. The modern construction is as follows: The wood wheel is made up in layers of ½-inch stock with the grain of alternate layers at right angles. The layers are glued together and held under pressure while both the wood and glue are hot. This construction lessens the likelihood of the wheel's changing shape due to the influence of heat or moisture. The wheel may be covered with a good quality of oak-tanned back strip leather, or bullneck; or if desired, felt may be used. These materials are pegged and cemented securely to the wood.

Leather and canvas are the materials most commonly used in polishing wheel construction. Bullneck leather wheels are made of oak-tanned bullneck leather cut into disks of uniform thickness and cemented together. The thickness of bullneck leather varies; the thin pieces of leather produce a wheel of hard density for use on one class of work, while the thicker bullneck leather, which may be from ½ to ¾ inch in thickness, produces softer wheels used for a different class of work. "Extra hard" leather wheels are made from split leather.

Canvas wheels are made in a variety of ways; in some the disks are cemented together, while in others they are hand-sewed or "quilted." Wheels that are cemented are very hard and used for rough coarse work, while those that are sewed may be made of varying densities by sewing together a larger or smaller number of disks into sections and gluing them. A more flexible canvas wheel is the hand-sewed form, made by sewing all the disks together to obtain the required face width. The sewed wheels are a very old style, and are used for carrying the coarser abrasives when performing rough polishing operations. The main objection to the use of wheels of this kind is that the twine with which they are sewed sometimes breaks under the hard pressures to which wheels of this kind are subjected. Copper wire is used in place of twine where the wheel is to be used under severe conditions. The layers of canvas in wheels other than the "solid cemented" or hand-sewed may be glued from the center outward for varying distances, depending upon how much spread is desired for the face of the wheel. Wheels in which the disks are held together by sewing and which are not stiffened by the use of glue, usually require metal side plates to support the canvas disks.

Muslin, Felt, Paper, Walrus Hide and Sheep-skin Wheels

Muslin wheels are made from sewed buffs glued together, the outer edges of the wheel often being left open or free from glue to give an open face to any desired depth. The sides of these wheels are supported by canvas disks. A polishing wheel of this type is softer than a hand-sewed canvas wheel.

Wool felt wheels are made from sheets of woven felt, ¼ inch thick, cemented together; this makes a flexible resilient wheel, the density of which may be varied by sewing two or more disks together and then cementing these to form

a wheel. Solid wheels made of Spanish or Mexican felt are quite popular for fine finishing work, but have little value as general utility wheels.

Paper wheels are made from strawboard paper disks and are cemented together under pressure to form a very hard wheel for rough work. Softer wheels are similarly made from felt paper. For those who are partial to the use of leather-covered wheels, a leather face may be cemented to these paper wheels as a substitute for leather-covered wood wheels. They will run true and retain their balance and shape, if properly used, for a long time.

Walrus leather, or sea-horse hide, is a suitable material for polishing wheels because of its thickness and its tough open fibers, which make it desirable for fine finishing wheels. Its thickness makes it possible for wheels up to 1½ inches face to be made up without seams. One general criticism of polishing wheels made from leather disks of any kind is that the grain side is usually harder than the flesh side, so that a wheel constructed of cemented leather presents a face that is uneven in hardness and that wears in ridges. This reduces the efficiency of the wheel and requires frequent truing up. As a result the life of the wheel is greatly reduced.

Sheep-skin polishing wheels may be made by cementing disks together, or by a loose construction in which the disks are sewed around the arbor hole only; or they may be hand-sewed. The cemented sheep-skin wheels are soft and pliable, and are used for fine finishing. The loose-disk sheep-skin wheels are suitable for even finer work and for buffing soft metals. The hand-sewed wheel is pliable and is used extensively in the jewelry trade; it is also suitable for buffing by the application of tripoli or other buffing compositions.

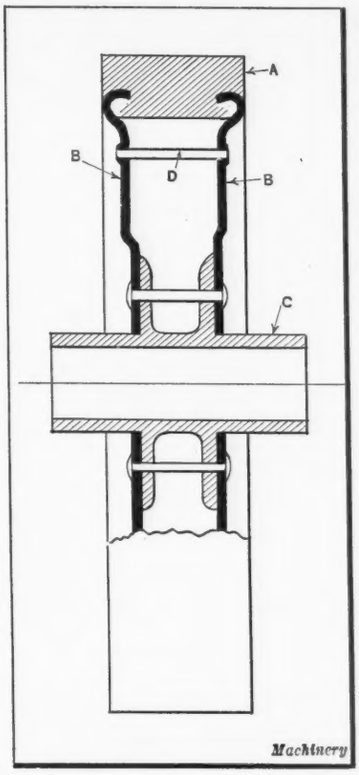
Vulcanite wheels, which are made from rubber and impregnated with abrasive, are sometimes used for polishing the flutes of reamers and the spiral grooves of drills and augers.

Materials for Buffs

As already mentioned, muslin polishing wheels are made from sewed buffs. In addition to their use for "cutting down" soft metals, buffs are regularly used for coloring various metals. They are made from all kinds of weaves and weights of cloth, and therefore vary greatly in their cutting or burnishing ability. There are two main classes of buffs, designated according to the method by which they are made—the "pieced-sewed" buffs, which are made from various weaves and weights of cloth, and the "full-disk" buffs, which are made from the best sheeting and shirting.

Bleached or unbleached cloth may be used according to the kind of surface for which the buff is intended. Bleached cloth is harder and stiffer than unbleached cloth, and is used for the faster cutting buffs the buff sections being made in plies of from eighteen to twenty thicknesses each. Coarsely woven unbleached cloth is recommended for highly colored work on soft metals, while the finer woven unbleached cloths are better adapted for the harder metals. The cloth used in buffs made for reliable service varies from 64 by 68 threads per square inch, to 92 by 96 threads. The material governs the ability of the buff to stand up in use, because the crocus, tripoli, rouge, and other cutting or coloring compositions should—for proper buffing—adhere to the ends of the threads instead of to the side of the cloth. Buffs may be sewed in any manner desired, but are usually sewed in spirals with the stitching ¼ or ⅜ inch apart.

A stiff buff, when working at the usual speed, is not suitable for "cutting down" soft metal or for use on light plated ware, but is used on the harder metals and for heavy nickel-plated articles. In the smaller sizes, a stiff buff may also be suitable for German silver, nickel, and white metal before it is plated. For buffing precious metals, wheels made of Canton flannel and wool are invariably used.



Cross-sectional View of Compress Polishing Wheel

"Compress" Polishing Wheels

Many attempts have been made to produce a polishing wheel that could be made to suit various requirements of finish and that would not be affected by atmospheric changes. It is apparent that a wheel that runs true and that does not vibrate at high rotative speeds is desirable, and that such a wheel would do better polishing and increase production. The "compress" type of polishing wheel with the material placed crosswise of the face of the wheel, instead of disk-wise, was designed with the idea of producing a wheel that would be suitable for all classes of work when made of the proper materials.

The compress wheel, a sectional view of which is shown herewith, is made of rectangular pieces of leather, canvas, felt, paper, or other material, arranged radially and compressed to form a ring or cushion *A* of polishing material of one or more inches in depth. This cushion of polishing material may be varied in density to suit the requirements. The cushion is assembled with two side plates *B* which engage annular recesses in the material and which are riveted to a cast-iron hub *C*, thus tying the whole together in a flexible wheel. This construction permits the cushion to be shaped to conform to the curvature or contour of the piece to be polished and makes it possible to maintain this shape.

The wheels are turned on a lathe, so that when put in use they can be accurately balanced; with proper care they will mantain this balance. The side plates *B* carry several brass tubes *D* riveted to them as shown. These tubes receive pieces of lead wire for balancing the wheel after "setting-up" with abrasive and glue. The material in the cushion, being placed on edge, permits the glue to set well and to hold the abrasive securely. The glue has an opportunity to penetrate into the material, whereas on a strap-covered wood wheel, for example, the glue cannot penetrate, but rather lies on the surface, so that no great resistance to the strain produced in polishing is offered.

The difficulty encountered with a leather-covered wheel when the leather becomes loose, due to the use of water and rollers in removing old abrasive, is not met with in the compress wheel. The trouble often experienced with solid wheels made out of disks cemented or sewed together, when the disks separate at the face and cause the glue to crack and break off, cannot be encountered with a wheel of the compress type. These wheels are made in sizes of from 2½ to 24 inches in diameter and in practically any width of face. A detailed description of the manufacture of compress and other types of polishing wheels will be given in a subsequent article.

Abrasive Materials

The abrasives used in polishing and flexible grinding operations may be broadly classified as natural and artificial. The natural abrasive is corundum. This mineral in the granular form is known as emery, but this is not pure corundum, as it contains certain impurities. These impurities render emery more suitable for fine finishing operations

than any artificial abrasive. The value of emery as an abrasive depends upon the percentage of alumina, or crystalline aluminum oxide, that it contains, as this is the only element in emery that is hard enough to cut metals effectively. The impurities that are present in emery are amorphous alumina, silica, iron oxide, and other metallic oxides.

Emery is known by the locality from which it is obtained. The percentages of the alumina contained in different kinds of emery used for polishing are: Naxos emery, 63 per cent; Turkish emery, 57 per cent; and Chester emery, 55 per cent. The natural mineral corundum may be crystallized in the electric furnace to produce an artificial abrasive of the same name, although, as generally known, corundum and emery are natural abrasives and are substantially the same mineral.

The artificial abrasives fall into two general classes—those composed of aluminum oxide in the crystalline form and those composed of silicon carbide. The aluminum oxide artificial abrasives are used for flexible grinding and polishing work, but the silicon carbide abrasives are used almost entirely in the form of solid grinding wheels. A special grade of artificial abrasive alundum, which is known as the TJ grade, has, according to the experience of Divine Bros. Co., given the best general satisfaction for all flexible grinding work with compress wheels. This grade of alundum is chemically treated in its manufacture so that the grains may be successfully held by glue.

For the finer finishing and coloring work, artificial abrasives are rarely used, and for this work natural emery finds general favor. One objection to the use of coarse numbers of artificial abrasives for polishing wheels has been the difficulty of holding the grains of the abrasives to the face of the wheels; but with care in the preparation of the wheels, and, particularly, in the correct use and treatment of a proper glue, artificial abrasives can be bonded to the polishing wheel securely enough to grind and polish the hardest metals. This phase of the polishing industry, relating to the preparation of the wheels for use, will be dealt with in a following article of this series.

Although it is sometimes claimed that artificial abrasives in the finer numbers are suitable for coloring purposes on such parts as surgical instruments, high-grade scissors, and hardware, the greater part of this work is done with natural emery. For fine finishing and coloring with artificial abrasives, or in fact, with any abrasive, it is well to remember that a higher degree of luster can be produced by using a slow speed and a more moderate cutting abrasive.

Other Materials Used in Polishing and Buffing

Pumice and rotten-stone may be regarded as abrasives, but their use is limited in the metal-finishing industries. Pumice is a hardened vulcanic product and rotten-stone is a substance obtained from limestone. Both these gritty materials are used for "cutting down" metals (such as white metal and German silver) that are subsequently to be plated. They are not bonded to the wheel but are applied to it by hand during the operation.

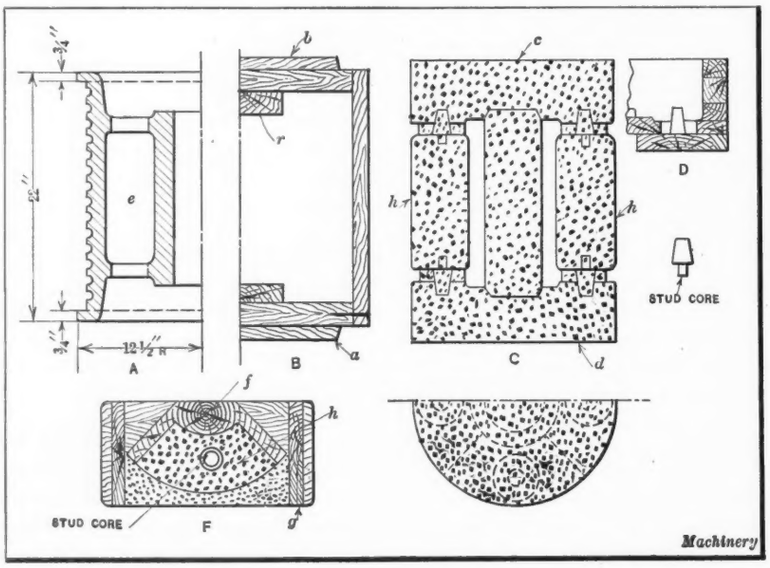
Tripoli is another abrasive used in finishing the surfaces of metal. It is easily pulverized, and is extensively used as a buffing material for "cutting down" soft metals that are to be plated. For coloring work with buffs, such materials as crocus, rouge, and Vienna lime are used. These are prepared in cake form with tallow, stearin, or petrolatum as a body. This composition adheres readily to the ends of the fabric used in the buffs. Crocus and rouge are metallic oxides and the lime is obtained by calcining limestone and certain kinds of shells.

* * *

MAKING PATTERNS FOR A WINDING DRUM BY HAND

By M. E. DUGGAN

Patterns that would ordinarily be turned up on a lathe are sometimes required to be made with hand tools. For example, the patterns for a winding drum such as shown in the half sectional view at *A*, were needed at a time when all the turning lathes were employed on important work. The patternmaker was therefore obliged to resort to the use of ordinary hand woodworking tools. The methods employed in constructing the pattern were rather unusual, although practical, and may be of interest to patternmakers handling similar work. The pattern was designed for molding on end, as this method gave a firm support for the necessarily heavy core. The result was a sound and true casting. Practically all the molding was done in the "drag flask," the cope being nothing more than a "flat back" except for the cope print impression.



Winding Drum Pattern and Cores made with Hand Woodworking Tools

The pattern for the drum is shown in the half sectional view at *B*. As but one casting was needed the drum was made with straight sides. This left considerable stock on the winding face of the casting which had to be removed in the machining operation, but the time thus saved in making the pattern and in molding more than compensated for the extra machine work. The pattern was constructed with top and bottom heads reinforced with cross-ribs, one of which is shown at *r* in the view at *B*. The cylindrical part of the pattern was made up of 1-inch square strips. The drag print indicated at *a* was securely fastened to the bottom head of the pattern, while the cope print *b* was pinned loosely to the top.

At *D* is shown a broken section of the core-box used to form the upper section *c* and the lower section *d* of the core shown in view *C*. The core that formed the "ring chamber" *e*, view *A*, was made in four sections. The core of one of these sections with its stud core in place is shown in the view at *F*. The core-box *f* and the black sand box *g* are shown in an inverted position with one of the four core sections *h* resting on the black sand bed. The core-box and the black sand box are lifted off before placing the core in the baking oven. The sectional view at *C* shows how the completed core was assembled in the mold.

The construction of this pattern is of particular interest in view of the fact that all the work was done with hand woodworking tools and a bandsaw.

Letters on Practical Subjects

JIGS FOR MOTORCYCLE CYLINDERS

The accompanying illustrations show two drill jigs used in machining cylinders for the Reading-Standard motorcycle. These cylinders are made of high-grade cast iron, and have a bore of 3⅜ inches and a piston stroke of 4 inches. The castings are bored and reamed to 3⅜ inches diameter (minus a grinding allowance of 0.012 inch), both sides of the flange are faced, and a "register" or sleeve is turned on the outer face of the flange. The valve, plug, and flange holes are then drilled, during which operation the work is located by means of the previously turned register and two wedges driven lightly between the jig and the sides of the flange.

After these holes have been drilled the jig illustrated is used for machining the nipples on the cylinders. In Fig. 1 the jig for the forward cylinder is shown. The casting is located by the flange register fitting into a recess in wall *A* and by a dowel-pin which enters one of the previously drilled holes. A hole is then drilled at *B* to suit a 1-inch S. A. E. standard thread. This is the intake manifold hole. The jig is next turned 90 degrees so that it is supported by leg *C* in such a position that the exhaust manifold hole *D* is in a vertical position. This hole is then machined with a hollow-mill to suit a 1⅞–24 threads per inch thread.

When performing similar machining operations on the rear cylinder casting, the work is located in a jig of the same type as that shown in Fig. 1. In this case also the casting is located in the jig by means of a turned register and a dowel-pin. The exhaust nipple, as shown in Fig. 2, is so located that it is necessary to cut away a section of the upper wall in order to admit the passage of the hollow-mill used in machining the hole. The sizes of both exhaust and intake manifold holes are the same as for the rear cylinder. This jig is also turned on its side when machining the intake nipple.

Providence R. I. ROBERT MAWSON

SAFETY CLUTCH FOR DRIVING PULLEY

Shear pins are used extensively as a means of preventing certain machines from being operated under excess loads. When a machine so equipped is overloaded, the pin is sheared and as a result the driving pulley is permitted to revolve on its shaft without operating the machine. Breakage of the machine itself is thus avoided. However, the necessity of replacing the shear pin before the machine can be again put in operation is an inconvenience that delays production. The safety clutch shown in the illustration is designed to overcome this undesirable feature. When disengaged, as a result of an overload being applied to the machine, this clutch can be quickly reset to the operating position.

The clutch and driving pulley complete are shown in the central view, while the views at the right and left show, respectively, the front and back of the clutch yoke. The pulley and driving yoke are omitted from the two latter

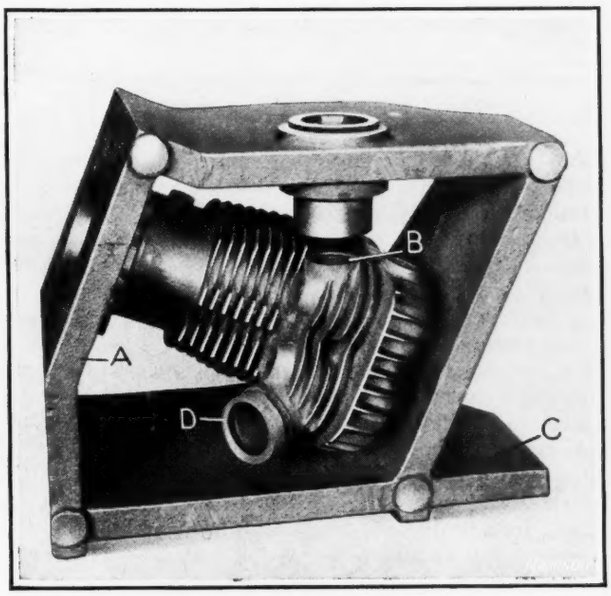


Fig. 1. Jig located for boring Intake Manifold Hole in Front Cylinder

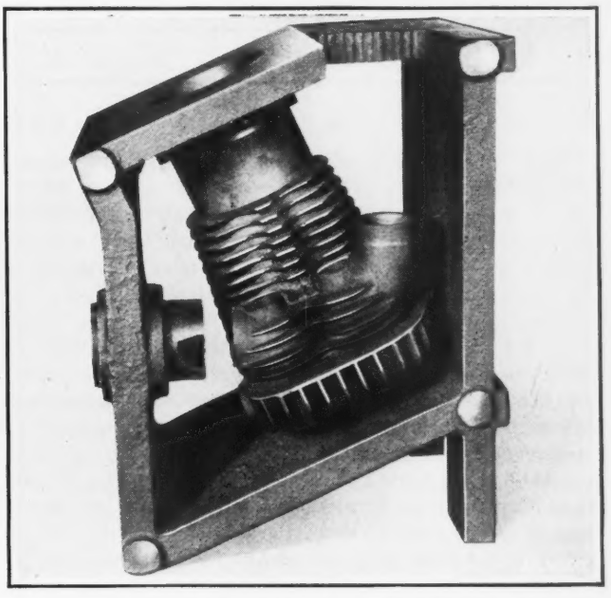


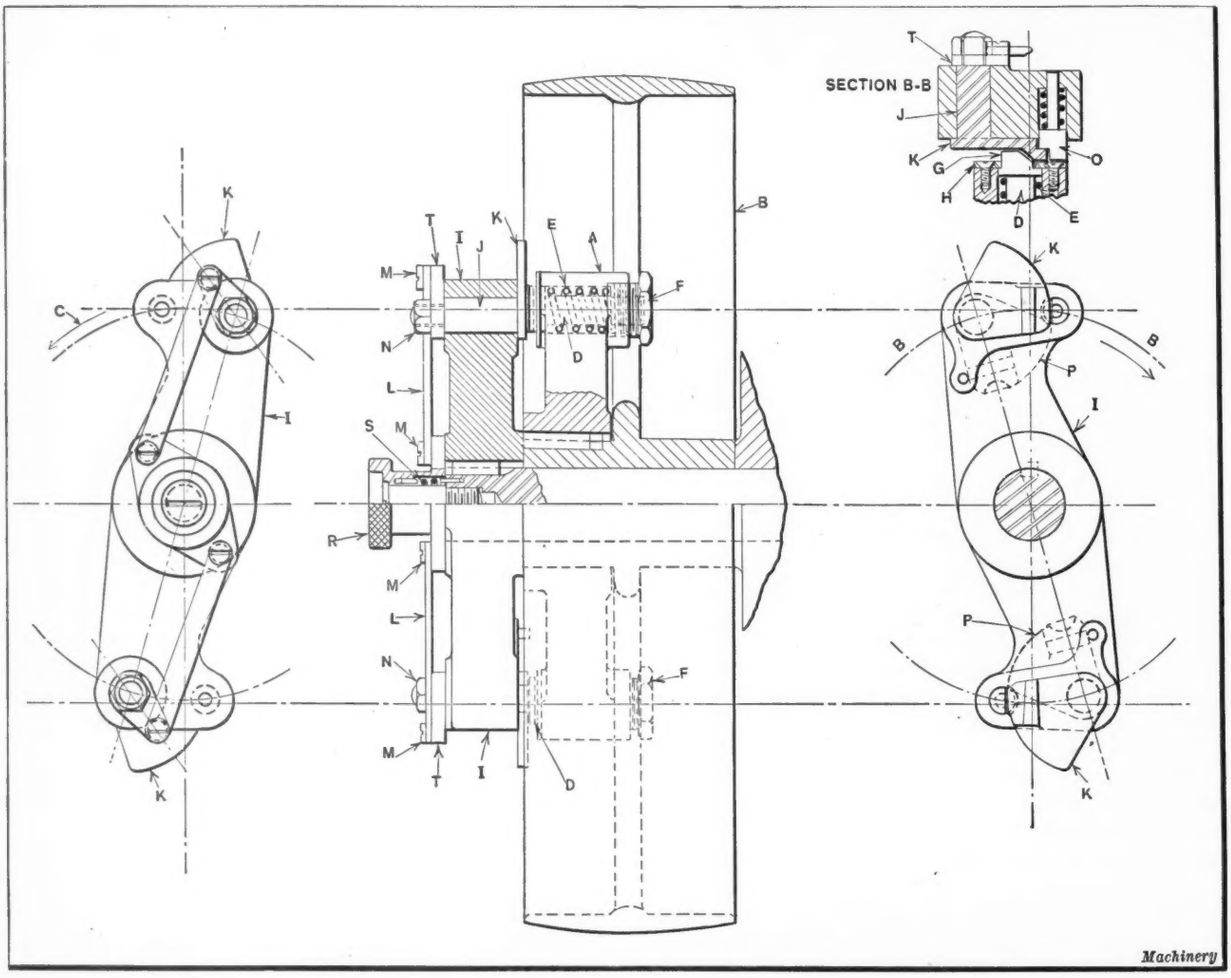
Fig. 2. Jig used for machining Exhaust Nipple on Rear Cylinder

views. The driving yoke *A*, being keyed to the pulley *B*, rotates with the latter member in the direction indicated by arrow *C*. In yoke *A* are two plungers *D* which have angular surfaces on their protruding ends, as shown in the sectional view in the upper right-hand corner of the illustration. These plungers are placed under a heavy tension by springs *E* which are held in place and adjusted by the nuts *F*. On the ends of the plungers at *G* are flats which fit into corresponding openings in the collar *H*. This construction prevents the plungers from turning or getting out of alignment. On the driven yoke *I* are two studs *J* located the same distance from the center of the driving shaft as the spring plungers *D*. On studs *J* are lugs or segments *K*, which are shown in the sectional view previously referred to. It will be noted that one side of each lug to the arms *T*, which are clamped to the studs *J* by means of nuts *N*. It will be evident from the construction that by turning knob *R* segments *K* will be brought into the driving position.

Fitchburg, Mass. E. E. LAKSO

TRUING UP A LATHE

In the following the writer will try to explain the reason for the inaccuracies observed in the test described in the article "Truing Up a Lathe Center," which appeared in August MACHINERY on page 991. Briefly, end play in the lathe spindle evidently caused the carefully ground centers to run out of true from 0.00025 to 0.0005 inch. In performing the grinding operation, the grinding wheel cuts "free,"



Safety Clutch for Driving Pulleys, which is so designed that it can be quickly reset to the Operating Position after being disengaged

is cut at an angle to correspond with the angle on the driving plungers *D*.

With the ordinary load, all parts remain in the position shown, but when the machine is subjected to an excessive overload, or some part of the machine fails to function, so that a greater driving force is required to operate the machine, the excessive pressure causes driving plungers *D* to be forced inward. This allows the plungers to ride over the driven lugs *K*. On passing over these lugs, plungers *D* force the small plungers *O* inward, thus releasing studs *J* from their position so that segments *K* are turned, by the pressure of spring *S*, to the positions shown by the dotted lines at *P* in the view at the right-hand side of the illustration. When in this position, segments *K* allow the driving plungers *D* to rotate with the pulley without making contact with their driving faces. To again engage the clutch, the knob *R* is given a slight turn in a clockwise direction. Knob *R* is connected by screws *M* and levers *L* there being no end thrust on the center which is being trued up. Also the wheel runs at a uniform rate of speed. If the grinding wheel is applied too suddenly at the beginning of the cut, it will cause the lathe spindle to oscillate endwise. This oscillation will continue as long as the wheel cuts freely and is fed at a uniform rate of speed; thus as a result of these oscillations there will be a high side on the center being trued.

To overcome this, the writer would suggest that just sufficient pressure be applied to the faceplate (near the center) to take up the end play. Proof of the explanation here given is found in the fact that the inaccuracies were corrected by applying a cast-iron lap to the center. The lap required pressure to do its work, and this pressure naturally took up the end play in the spindle. The remedy suggested will eliminate the cost of lapping and will give a true center.

Cleveland, Ohio WALTER H. STICKLER

PIERCING AND BLANKING DIE FOR SPACING COLLAR

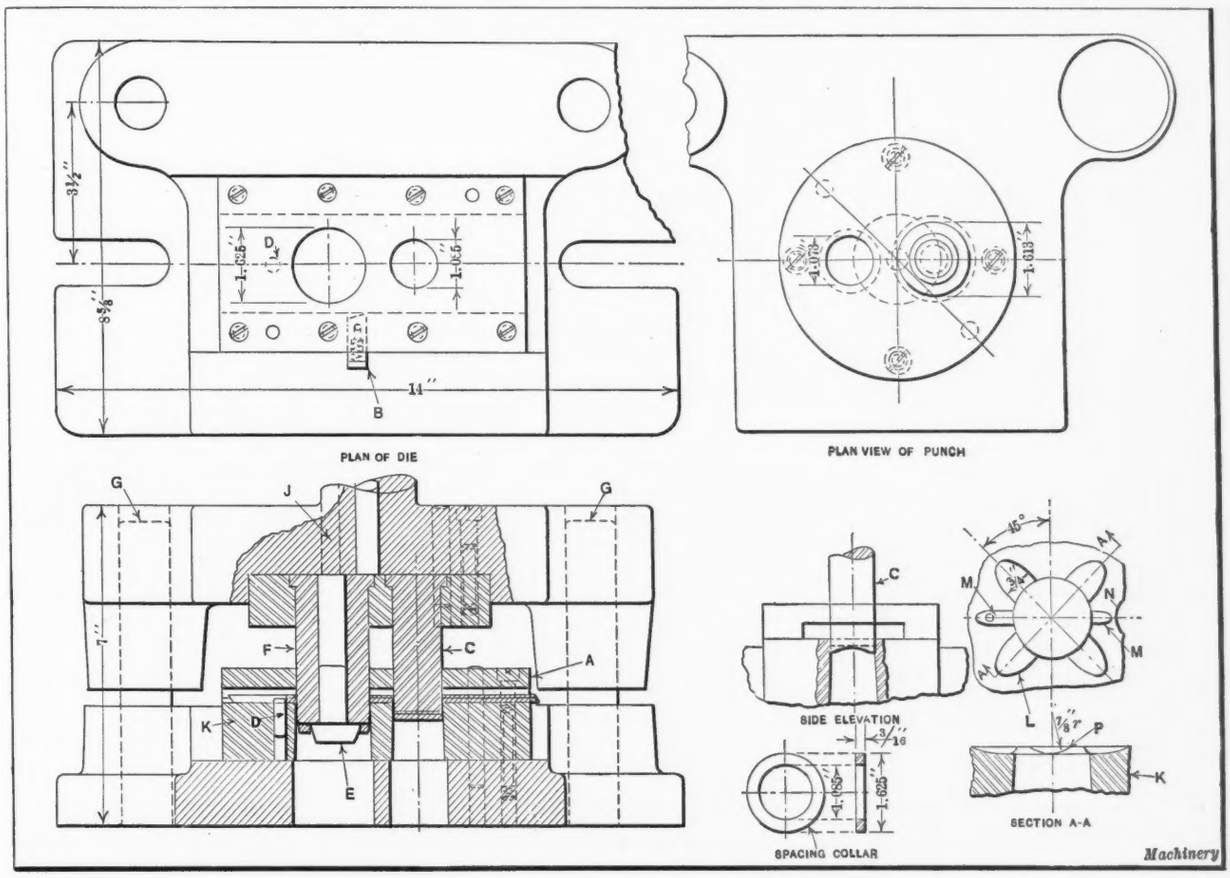
The progressive type of piercing and blanking die shown in the accompanying illustration is designed to produce spacing collars used in automobile construction. The material from which the washers are blanked is designated as "half hard" cold-rolled steel. It is 3/16 inch thick and is obtained in strips 2 inches wide by 36 inches long. The operations are piercing the 1.085-inch hole and blanking the 1.625-inch diameter indicated in the detailed view.

The strip stock is fed under the stripper plate *A* until its edge strikes finger-stop *B*, which is previously pushed in by the left hand of the operator. The press is then tripped, allowing punch *C* to pierce the 1.085-inch hole, after which the stock is again pushed forward until it strikes pin *D*. On the second stroke, pilot *E* enters the 1.085-inch hole, thus centering the stock while punch *F* blanks the 1.625-inch diameter.

The punch and die are aligned by means of pins *G*, which are driven into the die bed and made a good sliding fit in holes machined in the cast bosses of the punch-holder. Hole *J* in the punch-holder is provided to permit the pilot *E* to be pushed out, when the face of punch *F* is to be ground. Referring to the side elevation in the lower right-hand corner of the illustration, it will be noted that the cutting end of piercing-punch *C* is given shear. The amount of shear is about two-thirds the thickness of the strip stock. Blanking punch *F* is also given shear by making it longer than the piercing punch.

After the die had been in operation a short time, it was noticed that the blanking punch did not stand up well. In order to remedy this fault die *K* was also given shear as shown at *L* in the lower right-hand corner. As will be noted, the shear on the die consists of four grooves spaced 45 degrees apart and about ⅛ inch deep. These grooves were ground into the die on a surface grinder with a wheel dressed to a radius of ⅞ inch. The two grooves at *M* were made less deep than the others to avoid grinding into the piercing hole *N* of the die. The sharp corners at *P* were rounded by stoning the edges so as to prevent the die from tearing the metal.

Brooklyn, N. Y. J. A. HONEGGER



Punch and Die used for piercing and blanking Spacing Collars

REDESIGNING TRUNNION BEARING TO FACILITATE PRODUCTION

A few simple changes in the design of a trunnion bearing not only simplified the work of making the patterns, but also greatly facilitated the molding, casting, and machining operations. With the original design only a half bearing was cast at one time. The single half bearings were machined on a boring mill, and as no special holding fixture was provided, this operation proved a very trying one for the boring mill operator. The form of the single half bearing, as originally designed, is shown by the two full-line views in the upper half of the accompanying illustration (see next page).

At the suggestion of the boring mill operator, a change was made in the method of making the bearing. Instead of casting only a half bearing at a time, a full pattern was made with tie-pieces *A* and *B* connecting the two halves. This pattern was then split on the line *X*–*X*. The spaces between the two halves of the pattern at *C* and *D* were produced by dry sand cores. It will be noted that the 6¾-inch radius in the original design was struck from a center somewhat above the center of the bore. By referring to the full-line view at the left, it will be evident that practically all the outer pattern surface must be finished by hand.

By simply changing the design as indicated by the dotted lines in the lower half of the illustration, it was possible to eliminate much of the hand work required on the original pattern. Thus the surfaces finished to the 5¼-, 6½-, and

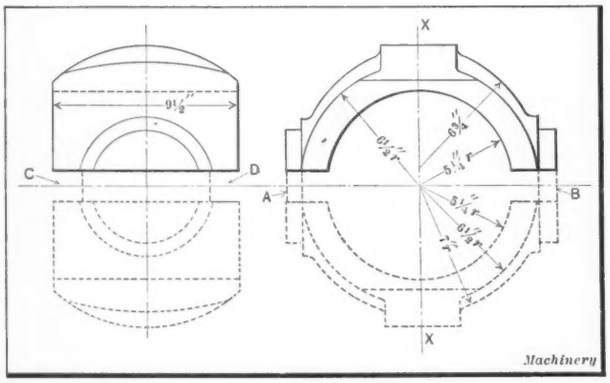


Illustration showing Change made in Trunnion Bearing Design

7-inch radii could be finished to size in the lathe. The addition or building on of the trunnions and saddle is a comparatively simple matter and is well understood by the patternmaker.

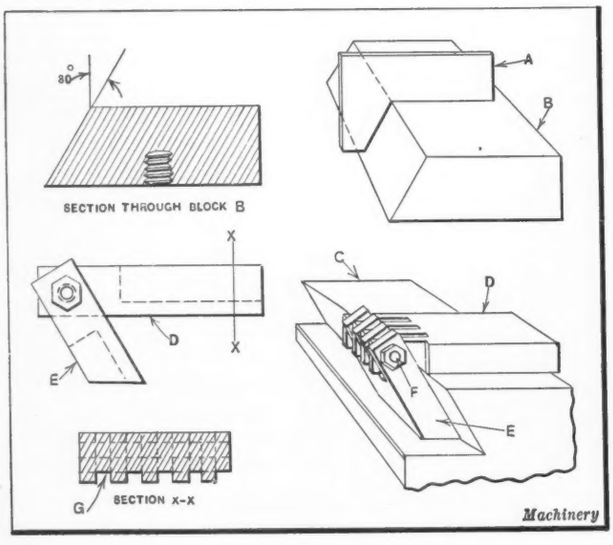
Kenosha, Wis. M. E. DUGGAN

LAPS FOR ANGLE-GAGES

In lapping angle-gages, difficulty is often experienced in making the two gaging surfaces come to a true or sharp edge. If the individual surfaces are lapped separately, this difficulty is increased. The writer believes that the best method of lapping an angle-gage, such as shown at *A* in the illustration, is to use a lapping block *B*, made of close-grained cast iron. The faces of this block should be tested on an accurate surface plate and the angle checked with a sine bar. The gage should be worked down to as nearly the required size as possible before it is finished on the lap.

The angle gage for work such as shown at *C* is much more difficult to machine and should be made of two hinged pieces *D* and *E*. The two separate parts of the lap are dovetailed and fastened together as shown. The bolt *F* clamps the pieces together when they are set to the correct angle. Grooves, such as indicated at *G* in the cross-sectional view *X-X*, are planed in the working faces of the lap. These grooves have the same spacing as the slots at the ends of pieces *D* and *E*, so that the amount of bearing surface in contact with the work will be uniform at all points. The two-piece adjustable lap can be trued up easily by grinding the lapping surfaces. The edge formed by the intersection of two surfaces can be lapped to a knife-edge with this type of lap. The widths of pieces *D* and *E* should be the same, but their lengths may be different.

Allentown, Pa. JOE V. ROMIG

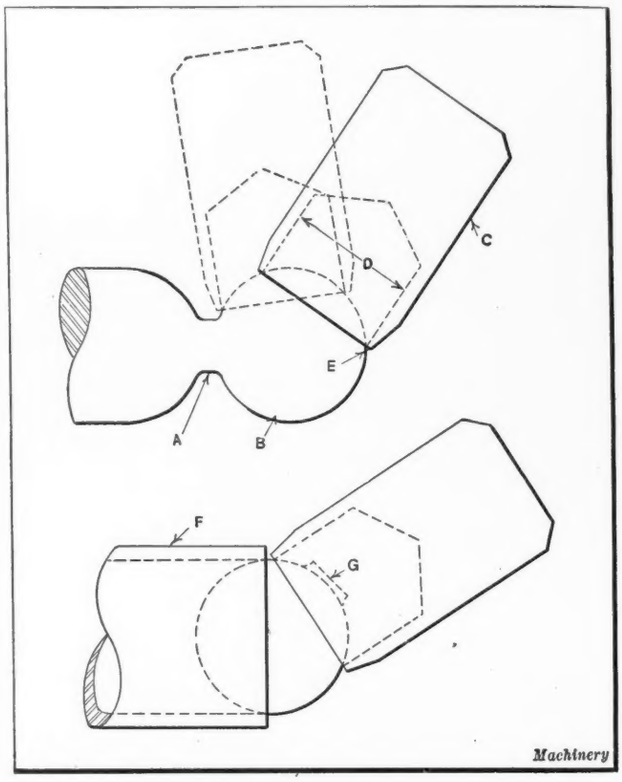


Laps for Angle-gages

TURNING A BALL IN THE LATHE

The turning of a ball or spherical surface in the lathe is rather difficult unless a special ball-turning device is employed. Even with a special device considerable skill is necessary to produce an accurate ball. Quite good results may be obtained, however, by the method here illustrated. First, turn the stock down to form a ball *B* of nearly the desired size, leaving a neck *A* as indicated in the upper view of the illustration. Calipers are employed, of course, to test the partly turned ball *B*, so that it will be made as nearly round as possible.

The next step is to smooth up the turned surface with the ball-forming tool shown at *C*. If the ball is to be 1½ inches in diameter the inside diameter *D* of the tool *C* should be about 1¼ inches. The ball-forming tool should be made of a good quality of tool steel, and hardened. The end *E* of the tool should be ground so that it is at right angles to the axis. The tool may be made any length that



Method of forming a Ball in a Lathe

can be conveniently held in the hand. The sharp edge of the tool, which is brought in contact with the work as indicated, produces a smooth surface.

After the ball is partly finished, it is cut off and driven into a tube held in the lathe chuck. The tube into which the ball is driven is shown at *F* in the lower view of the illustration. Before driving the ball into place, the tube is bored out to a diameter a little less than that of the ball and given a slight taper. The projecting neck *G* should be located at an angle of about 45 degrees with the axis of the tube. This projection can be removed by taking very light cuts, using the finished surface as a guide in feeding the tool. The tool *C* is then used to smooth up the work. A very accurate ball can be made by repeatedly relocating the ball in the tube *F*, if the smoothing tool *C* is carefully used each time the ball is relocated. If the ball is to be hardened and ground, a tool similar to the one shown at *C*, but of soft steel or brass, can be used for grinding. This tool should be chamfered on the working edge so that it can be effectively used with an abrasive.

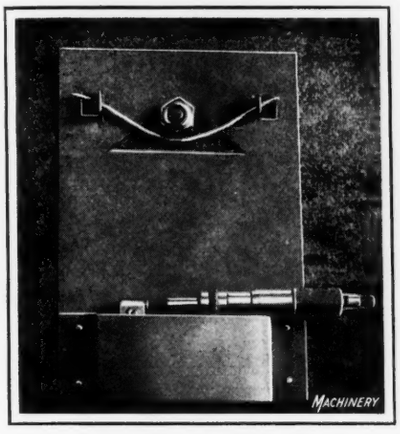
Butte, Mont. E. W. CABLE

Shop and Drafting-room Kinks

HOLDER FOR MICROMETER

It is often convenient to have some other place for holding a micrometer when not in use than in the pocket of an apron, overalls, or shop coat. Although many mechanics are careful in handling instruments of precision, such as micrometers, nevertheless they are often found lying around on machines. Some mechanics do not like to carry instruments in a pocket of their shop clothing because they are likely to fall out when the men stoop or lean over their work. The accompanying illustration shows a convenient method of holding a micrometer, so that it need not be left around where it can become mislaid or damaged.

This holder is made of sheet metal, the pocket at the bottom being wide enough to admit the frame of the micrometer with the barrel resting as shown. This prevents the instrument from falling through, which it otherwise might do, as the pocket has no bottom. With this construction, any stray chips are free to drop through so that there can be no accumulation of dirt in the pocket. The section forming the pocket is attached by four pins which are riveted over. Near the top of the holder there is a triangular section cut away, and on each side of this hole a square hole is cut, the metal being bent out at right angles. A hole is drilled through each of these bent projections to accommodate a piece of spring wire, the ends of which, after being passed through the holes, are flattened to keep them in place.



A Convenient Micrometer-holder

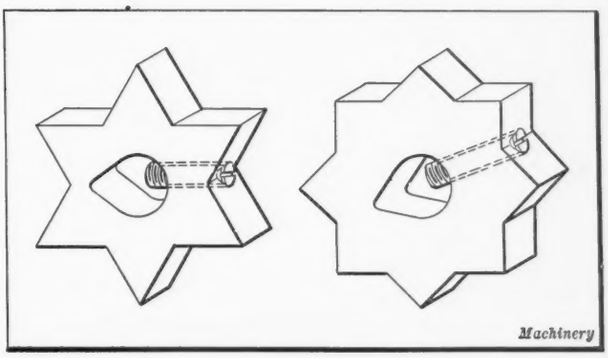
In the shop where this holder is used, it is taken around from machine to machine as desired and the spring snapped over a nut, bolt-head or pin, whichever is most convenient. The tension of the spring is great enough to furnish a firm contact with the nut, bolt-head or pin, which effectively prevents it from being displaced by vibration of the machine.

Montreal, Canada — HARRY MOORE

INDEXING IN THE VISE

In the average tool-room and in small job shops, it is often desired to mill flats on opposite sides of a round piece, or square the end, or perhaps cut three or four flutes in a reamer. For such work, more time is generally spent in setting up the dividing head and tail-center than in performing the actual machining operations. The accompanying illustration shows a pair of blocks which will enable indexing of plain work to be done in the ordinary vise.

With these blocks, two, three, four, six, and eight divisions (which are the ones usually required) can be made with a fair degree of accuracy. One of these blocks, when in use is clamped on the end of the shaft or piece to be machined, and one set of faces leveled with an indicator surface gage placed on the table. After the first cut, the vise is loosened and the work turned until the next face to be used is level.



Blocks for indexing Work held in Vise

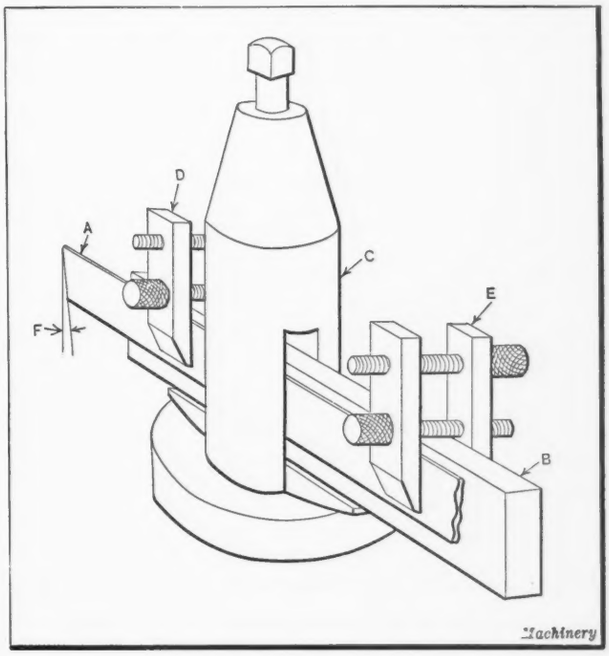
This procedure is repeated until the required number of cuts has been taken. Irregular spacing such as is often required in milling flutes in reamers can also be readily obtained with indexing blocks of the type shown.

Rochester, N. Y. — GEORGE C. HANNEMAN

CUTTING-OFF TOOL FOR NARROW CUTS

The accompanying illustration shows a cutting-off tool made from a piece of a power hacksaw blade. For fine work a regular hand hacksaw blade could be used. Blade *A* is ground at one end to give the required clearance angle *F*, and is clamped to a piece of bar stock *B* or to a regular tool-holder which is narrow enough to permit both the blade and the holder to be slipped through the slot in the toolpost *C*. Clamp *D* is placed in front of the toolpost, and another clamp *E* at the rear, as shown. The clamp *D* is located near the cutting end of the blade to prevent the blade from being unduly deflected. Such a tool is convenient for cutting brass tubing, nuts, and other pieces from bar stock when it is desired to keep the amount of waste as low as possible.

Oakland, Cal. — H. H. PARKER



Improvised Cutting-off Tool made from Hacksaw Blade

TABLE 1. GLEASON WORKS SYSTEM FOR GENERATED SPIRAL BEVEL GEARS

For Spiral Bevel Gears Operating at Right Angles, where the Pinion is the Driver and has Less than Ten Teeth

The proportions given have been based on the assumption that the spiral angle used is 30 degrees. In order to obtain the desired tooth action it is recommended that the spiral angle selected should not be less than 27 degrees.

Working Depth, Whole Depth, Pressure Angle

For Combinations having	Working Depth, Inches	Whole Depth, Inches	Pressure Angle, Degrees
9 teeth in pinion	$\frac{1.700}{D.P.}$	$\frac{1.888}{D.P.}$	17½
8 teeth in pinion	$\frac{1.600}{D.P.}$	$\frac{1.788}{D.P.}$	17½
7 teeth in pinion	$\frac{1.600}{D.P.}$	$\frac{1.757}{D.P.}$	20
6 teeth in pinion	$\frac{1.500}{D.P.}$	$\frac{1.657}{D.P.}$	20
5 teeth in pinion	$\frac{1.400}{D.P.}$	$\frac{1.557}{D.P.}$	20

Addendum and Dedendum

For 9 teeth in pinion, addendum of gear = Addendum for 1 D.P. (Table 2) ÷ D.P.

For 8 teeth in pinion, addendum of gear = (Addendum for 1 D.P. ÷ D.P.) × (80 ÷ 85)

For 7 teeth in pinion, addendum of gear = (Addendum for 1 D.P. ÷ D.P.) × (80 ÷ 85)

For 6 teeth in pinion, addendum of gear = (Addendum for 1 D.P. ÷ D.P.) × (75 ÷ 85)

For 5 teeth in pinion, addendum of gear = (Addendum for 1 D.P. ÷ D.P.) × (70 ÷ 85)

For all combinations, addendum of pinion = working depth — addendum of gear.

For all combinations, dedendum of gear = whole depth — addendum of gear.

For all combinations, dedendum of pinion = whole depth — addendum of pinion.

Circular Thickness

For 9 teeth in pinion, circular thickness of gear = $\frac{0.976''}{D.P.} + (0.7 \times \text{addendum of gear}) - \frac{K \text{ (Table 2)}}{D.P.}$

For 8 teeth in pinion, circular thickness of gear = $\frac{1.011''}{D.P.} + (0.7 \times \text{addendum of gear}) - \frac{K}{D.P.}$

For 7 teeth in pinion, circular thickness of gear = $\frac{0.931''}{D.P.} + (0.8 \times \text{addendum of gear}) - \frac{K}{D.P.}$

For 6 teeth in pinion, circular thickness of gear = $\frac{0.971''}{D.P.} + (0.8 \times \text{addendum of gear}) - \frac{K}{D.P.}$

For 5 teeth in pinion, circular thickness of gear = $\frac{1.011''}{D.P.} + (0.8 \times \text{addendum of gear}) - \frac{K}{D.P.}$

For all combinations, circular thickness of pinion = 3.142 — circular thickness of gear

Machinery

TABLE 2. GLEASON WORKS SYSTEM FOR GENERATED SPIRAL BEVEL GEARS

Addendum for 1 Diametral Pitch

To obtain addendum select from table value corresponding to ratio given by the following formula:

$$\text{Ratio} = \frac{\text{Number of teeth in gear}}{\text{Number of teeth in pinion}}$$

Ratios From	Ratios To	Addendum, Inch	Ratios From	Ratios To	Addendum, Inch	Ratios From	Ratios To	Addendum, Inch	Ratios From	Ratios To	Addendum, Inch
1.00	1.00	0.850	1.15	1.17	0.750	1.41	1.44	0.650	1.99	2.10	0.550
1.00	1.02	0.840	1.17	1.19	0.740	1.44	1.48	0.640	2.10	2.23	0.540
1.02	1.03	0.830	1.19	1.21	0.730	1.48	1.52	0.630	2.23	2.38	0.530
1.03	1.05	0.820	1.21	1.23	0.720	1.52	1.57	0.620	2.38	2.58	0.520
1.05	1.06	0.810	1.23	1.26	0.710	1.57	1.63	0.610	2.58	2.82	0.510
1.06	1.08	0.800	1.26	1.28	0.700	1.63	1.68	0.600	2.82	3.17	0.500
1.08	1.09	0.790	1.28	1.31	0.690	1.68	1.75	0.590	3.17	3.67	0.490
1.09	1.11	0.780	1.31	1.34	0.680	1.75	1.82	0.580	3.67	4.56	0.480
1.11	1.13	0.770	1.34	1.37	0.670	1.82	1.90	0.570	4.56	7.00	0.470
1.13	1.15	0.760	1.37	1.41	0.660	1.90	1.99	0.560	7.00	∞	0.460

Values of K for Circular Thickness Formula

Select value corresponding to number of teeth in pinion and ratio given by formula.

Number of Teeth in Pinion	Ratios 1.00 to 1.25	1.25 to 1.50	1.50 to 1.75	1.75 to 2.00	2.00 to 2.25	2.25 to 2.50	2.50 to 2.75	2.75 to 3.00	3.00 to 3.25	3.25 to 3.50	3.50 to 3.75	3.75 to 4.00	4.00 to 4.50	4.50 to 5.00	5.00 and higher
	Values of K (in inches) for Different Ratios														
9	0.000	0.010	0.025	0.040	0.055	0.070	0.085	0.095	0.105	0.115	0.125	0.135	0.150	0.165	0.185
8	0.000	0.010	0.030	0.045	0.065	0.080	0.095	0.110	0.125	0.135	0.145	0.155	0.170	0.180	0.195
7	0.000	0.025	0.050	0.075	0.095	0.115	0.135	0.155	0.170	0.185	0.195	0.205	0.220	0.235	0.250
6	0.010	0.035	0.060	0.085	0.105	0.130	0.150	0.165	0.180	0.195	0.210	0.220	0.235	0.250	0.265
5	0.020	0.040	0.075	0.110	0.135	0.155	0.170	0.185	0.200	0.215	0.230	0.240	0.255	0.270	0.285

Machinery

The Gleason Works System of Bevel Gears*

By F. E. McMULLEN and T. M. DURKAN, of the Gleason Works, Rochester, N. Y.

THE Gleason Works system of bevel gears was designed with the idea of securing the quietest form of tooth consistent with strength and wearing qualities, as explained previously in an article descriptive of this system, which appeared in June, 1922, MACHINERY, beginning on page 788. When this system was first introduced, the tables of formulas and data for determining the tooth proportions applied to driving pinions having ten teeth or more.

The accompanying tables represent an addition to this system in that they give the tooth proportions for smaller numbers of teeth in spiral bevel pinions than were included in the tables previously published. In addition, the Gleason Works have prepared a table of outline factors for both spiral and straight bevel gears. These factors are used in connection with the well-known Lewis formula for calculating the strength of bevel gears, and were obtained by considering the load applied at the outer end of a tooth proportioned according to the Gleason Works system.

As previously explained, the point of application of the load, according to the Gleason Works system, should be determined for each combination, since it is a function of the number of teeth in contact. The calculated strength of gears, based upon this method of load application, is greater than that obtained by the Lewis method, the increase in some cases being as much as 100 per cent. However, in view of the fact that the Lewis formula is universally known, it was considered desirable to present, at this time, values determined by the Lewis method.

It is recommended that this subject be thoroughly investigated to determine the exact influence of the number of teeth in contact, on the strength of bevel gears, especially in view of the recognized fact that the Lewis method gives ultimate loads that are less than the breaking loads found in actual practice.

*Addition to the Gleason Works system of bevel gears, presented at the convention of the American Gear Manufacturers' Association held in Chicago, October 9 to 11.

TABLE 3. OUTLINE FACTORS Y FOR GLEASON WORKS SYSTEM

For use in the Lewis Formula as given on page 640 of MACHINERY'S HANDBOOK, these values are for either gear or pinion.

STRAIGHT BEVEL GEARS

Number of Teeth in Pinion	Ratios 1.00 to 1.25	1.25 to 1.50	1.50 to 1.75	1.75 to 2.00	2.00 to 2.25	2.25 to 2.50	2.50 to 2.75	2.75 to 3.00	3.00 to 3.25	3.25 to 3.50	3.50 to 3.75	3.75 to 4.00	4.00 to 4.50	4.50 to 5.00	5.00 to ∞
	Values of Y for Lewis Formula														
10	0.231	0.260	0.280	0.294	0.305	0.315	0.324	0.332	0.340	0.347	0.353	0.358	0.365	0.371	0.377
11	0.268	0.264	0.273	0.286	0.296	0.303	0.309	0.315	0.320	0.324	0.328	0.332	0.336	0.340	0.342
12	0.248	0.265	0.281	0.295	0.308	0.318	0.328	0.335	0.341	0.345	0.348	0.351	0.353	0.355	0.356
13	0.264	0.278	0.291	0.280	0.278	0.286	0.291	0.295	0.298	0.299	0.301	0.303	0.305	0.307	0.310
14	0.242	0.254	0.263	0.272	0.281	0.288	0.294	0.299	0.304	0.307	0.310	0.313	0.316	0.318	0.319
15	0.248	0.258	0.266	0.274	0.283	0.290	0.296	0.301	0.305	0.308	0.312	0.315	0.318	0.319	0.320
16	0.252	0.261	0.269	0.277	0.285	0.292	0.298	0.304	0.308	0.312	0.314	0.317	0.319	0.321	0.323
17 to 18	0.257	0.265	0.273	0.281	0.288	0.295	0.302	0.307	0.311	0.315	0.318	0.320	0.322	0.325	0.326
19 to 21	0.265	0.272	0.279	0.286	0.294	0.300	0.307	0.312	0.317	0.320	0.324	0.326	0.328	0.330	0.332
22 to 25	0.274	0.281	0.288	0.295	0.301	0.307	0.314	0.319	0.324	0.327	0.331	0.332	0.335	0.337	0.338
26 to 30	0.284	0.291	0.297	0.304	0.310	0.317	0.322	0.327	0.332	0.336	0.339	0.342	0.344	0.346	0.347

SPIRAL BEVEL GEARS

Number of Teeth in Pinion	Ratios 1.00 to 1.25	1.25 to 1.50	1.50 to 1.75	1.75 to 2.00	2.00 to 2.25	2.25 to 2.50	2.50 to 2.75	2.75 to 3.00	3.00 to 3.25	3.25 to 3.50	3.50 to 3.75	3.75 to 4.00	4.00 to 4.50	4.50 to 5.00	5.00 to ∞
	Values of Y for Lewis Formula														
5	0.297	0.322	0.343	0.361	0.376	0.388	0.398	0.406	0.411	0.416	0.420	0.424	0.431	0.438	0.450
6	0.310	0.332	0.353	0.372	0.386	0.398	0.406	0.414	0.419	0.424	0.428	0.431	0.436	0.443	0.452
7	0.318	0.333	0.347	0.360	0.373	0.384	0.392	0.398	0.405	0.410	0.415	0.419	0.426	0.432	0.439
8	0.298	0.320	0.336	0.348	0.357	0.366	0.373	0.379	0.384	0.388	0.392	0.394	0.397	0.400	0.405
9	0.292	0.313	0.327	0.338	0.346	0.352	0.357	0.363	0.367	0.370	0.373	0.376	0.380	0.384	0.388
10	0.315	0.338	0.353	0.363	0.371	0.345	0.326	0.342	0.351	0.357	0.363	0.367	0.371	0.374	0.377
11	0.316	0.335	0.343	0.325	0.327	0.333	0.338	0.344	0.350	0.356	0.361	0.367	0.375	0.384	0.390
12	0.298	0.318	0.333	0.343	0.351	0.357	0.363	0.368	0.372	0.377	0.379	0.381	0.384	0.386	0.388
13	0.302	0.320	0.334	0.343	0.351	0.358	0.365	0.371	0.376	0.381	0.384	0.386	0.388	0.391	0.393
14	0.306	0.322	0.334	0.345	0.354	0.362	0.369	0.374	0.378	0.382	0.386	0.389	0.391	0.393	0.395
15	0.314	0.330	0.342	0.352	0.360	0.368	0.374	0.380	0.385	0.389	0.392	0.394	0.397	0.399	0.402
16	0.322	0.335	0.347	0.358	0.367	0.374	0.381	0.386	0.390	0.394	0.397	0.400	0.402	0.404	0.406
17 to 18	0.329	0.343	0.354	0.364	0.373	0.382	0.389	0.394	0.398	0.400	0.403	0.406	0.407	0.409	0.410
19 to 21	0.339	0.351	0.362	0.373	0.382	0.389	0.396	0.401	0.405	0.407	0.410	0.411	0.412	0.414	0.415
22 to 25	0.351	0.363	0.373	0.382	0.391	0.398	0.403	0.407	0.410	0.412	0.413	0.414	0.415	0.417	0.418
26 to 30	0.364	0.374	0.384	0.393	0.399	0.404	0.407	0.410	0.412	0.414	0.415	0.416	0.417	0.418	0.419

The Machine Tool Industry

THE steady, although slow, improvement in the machine tool industry noted in this review from month to month during the last six months continues. Prices have advanced in practically all lines of shop equipment, the advances averaging from 10 to 15 per cent over the prices prevailing in the latter part of 1921. These advances have stimulated buying, especially by the railroads. Several lists of railroad shop equipment held up for a year or more, partly because purchasing agents expected still lower machine tool prices, have been released. In the Middle West, particularly, substantial railroad business has been placed.

Present indications are that there will be further price advances, because costs of materials have risen considerably, and the class of labor required in machine tool shops is scarce. Hence, there can be no reduction in costs, but it is more likely that costs will go up, for the machine tool builder must compete with his customers for labor and must pay at least as high rates as are paid in machine shops engaged in building automobiles, locomotives, washing machines, and hundreds of other plants using machine tools. He must also compete for his labor with other industries that in the past paid a lower wage than that paid to a good machinist—like textile mills and shoe factories—but that now in many instances pay wages higher than the machine tool builder can afford to pay, unless there is a further advance in prices. Anyone wishing to prove these facts for himself should simply compare the price per pound paid for machinery outside of the machine tool field with the price of machine tools. It is surprising how many lines of machinery there are requiring only the simplest kind of construction and workmanship which sell at prices per pound net weight that are double or more than double those of machine tools.

Conditions in the Industry

One of the favorable conditions in the machine tool industry—and one that will soon have a marked effect on the activity of the shops in this field—is that the large stocks of equipment accumulated in the earlier part of the business depression have been gradually worked off, and many manufacturers now find it necessary to resume the building of new lots of machines for stock. There is some hesitancy as to the desirability of again accumulating stock; but it is practically a necessity, because buyers expect prompt deliveries, and instances are on record where orders have been lost because the manufacturer was not in a position to quote early delivery. Furthermore, there is less danger in building for stock at present wages and material costs than when these were at their peak; and stocks built now are likely to be produced as cheap as, if not cheaper than, later on. The labor market is becoming more and more difficult, and the machine tool builder who can begin now to build up an organization, by gradual steps, is likely to be in a better position than the manufacturer who is forced suddenly to put a large force together when business is pressing him.

The second-hand market is practically normal now, and only in certain centers is there what might be termed a surplus of used machinery. In Dayton and Columbus, for example, where many of the tool shops that started during the war have gone out of business, there are many good used machines to be had; but in most places used machines of good quality and in good condition have been absorbed. The Government has practically nothing more to offer, except some special machinery and some of the shipyard equipment which is not of general application.

In new equipment, the automotive industries are still the consumers of the greatest volume; but the railroads, and the locomotive shops, have also placed some fair-sized orders.

The Automobile Shop Demand

The automobile industry shows no sign of slackening its pace, although the business done is chiefly in the hands of a few large well-known companies. The weeding out process is still at work, and it is a case of the survival of the fittest. Builders of the best and most reliable cars who sell them at reasonable prices are doing a very good business, while the speculators and mere money-makers who rode in on the high tide of prosperity are being crowded out. This is a normal development of the industry. There are no advantages to be gained in having a great variety of makes of automobiles. It would be futile to attempt to predict how many makers of cars will ultimately dominate the market, but it is a fact that even now a dozen companies make practically all the cars in the country. The remainder, even though some make excellent automobiles, produce a comparatively small number. These leaders are constantly expanding, or securing new and up-to-date equipment; and several machine tool builders depend almost solely on this industry, at least two plants running at capacity on equipment of this kind.

Combating Trade Abuses

During periods of depression, the buyer always has an advantage over the seller. This has been especially true in the machine tool industry during the past year. Purchasing agents have pitted sellers against each other, not always by fair means or scrupulously truthful statements. In many cases they have told of concessions offered by a competitor of the seller that had no foundation in fact. Manufacturers and salesmen would do well to investigate statements of this kind before acting upon them. If it is illegal, as it should be, to combine to maintain prices, it certainly is unfair practice to force prices down by untruthful statements. Buyers as well as sellers should be legally responsible for trade abuses that interfere with open and free competition.

Some buyers, taking undue advantage of the manufacturer competing for orders in a hard market, have tried to impose the condition that new and improved equipment developed later must not be sold to a competitor. Such conditions have generally been rejected by the manufacturer. He cannot afford to place upon his inventive ability and experience what amounts to a mortgage. He cannot afford and should resolutely refuse to limit the equipment he develops to a single customer.

Another difficulty frequently met with is the excessive demand for free service. Those who manufacture a line of machines where competition is not too keen may be able to recover the cost of this free service in the selling price of the machine. But in many lines the price of the machine covers nothing but actual manufacturing costs; in such instances, free service becomes a serious problem. There is also the matter of the engineering lay-outs that are submitted before an order is placed; these, in many cases, take on the character of consulting engineering service, and it is an open question whether manufacturers are not justified in making such service contingent upon a subsequent order—that is, if an order for the equipment is placed, the service in planning methods of production is free; but if the prospective customer does not place an order, this service should be charged for the same as any other consulting engineering service.

New Machinery and Tools

The Complete Monthly Record of New Metal-working Machinery

The New Tool descriptions in MACHINERY are restricted to the special field the journal covers—machine tools and accessories and other machine shop equipment. The editorial policy is to describe the machine or accessory so as to give the technical reader a definite idea of the design, construction, and function of the machine, of the mechanical principles involved, and of its application.

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Pratt & Whitney Centering Machines

CENTERING the ends of small-diameter quantity-production work may be performed at high production rates by means of an automatic centering machine lately developed by the Pratt & Whitney Co., Hartford, Conn. This machine is equipped with two drill heads for simultaneously drilling both ends of the work. It has been designed primarily for use in conjunction with the automatic lathe manufactured by this company, which was described in December, 1921, MACHINERY, but it may also be used as auxiliary equipment to other machine tools. The work is fed from a magazine into alignment with the centering spindles by means of a transfer mechanism, the movements of which are correlated with the feeding and withdrawing movements of the drill spindles. The work is clamped automatically, the only requirement of the operator being to keep the magazine loaded and remove the finished parts

Fig. 1. Pratt & Whitney Automatic Centering Machine which simultaneously drills Both Ends of Work

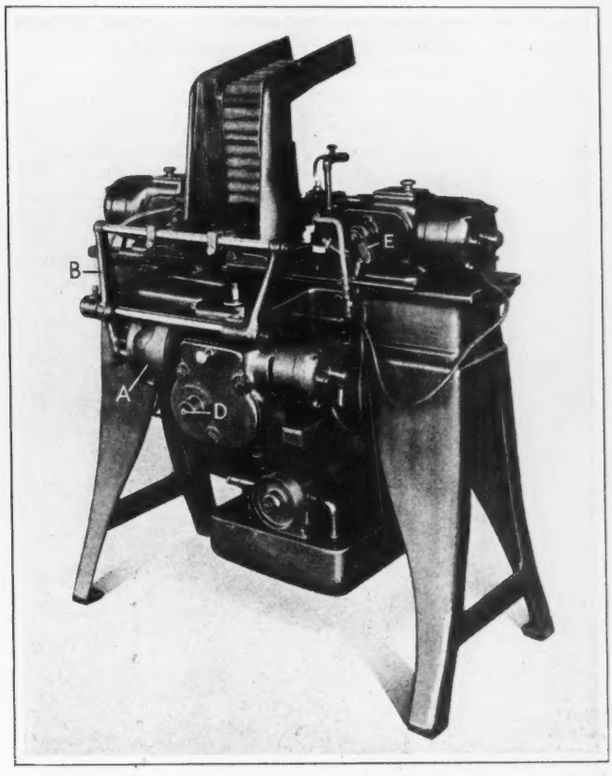


Fig. 2. Rear View of Machine, showing Mechanism for transferring Work and feeding Drill Spindles

as the work-box becomes full. The Pratt & Whitney Co. is at this time also introducing to the trade a new model hand-centering machine (similar to the automatic type), a description of which will be included in the present article.

Automatic Centering Machine

From Figs. 1 and 2 it will be seen that the two drill heads mounted on opposite sides of the bed are individually driven by a motor integral with each head. These motors are geared to the drill spindles in such a way that spindle speeds of either 1200 or 1800 revolutions per minute may be secured. The selection of these speeds and locking of the spindle during the replacement of drills is accomplished by means of a knob on top of each drill head. The magazine and work supports are attached to the head castings, and so in setting the machine to accommodate different lengths of work, it is only necessary to move the heads to the proper positions along the bed. The sides of the magazine are readily adjustable to suit work of different diameters, from ¼ to 1½ inches.

The automatic feeding of the drills is accomplished by means of cam *A*, Fig. 2, which is driven by the small motor at the rear of the machine. This cam, through lever *B* and several rods, also actuates two transfer plates, one of which may be seen at *C*, Fig. 3. These plates bring the work forward into alignment with the drill spindles. A set of change-gears provides a means of regulating the drilling time to suit the work. The drills are automatically withdrawn twice while drilling so as to clear the holes of chips and permit oil to enter. The feeding movement of each spindle may be varied from 7/16 to ⅞ inch by setting the regulator lever *E*, Fig. 2, to suit. After the machine has been set up, its cycle of operations may be checked by turning by hand a crank handle placed on the square end of shaft *D* which projects from the change-gear box.

Depth Stops and Self-adjusting Vise

Adjustable stops on the drill heads bear against the ends of the work to limit the forward movement of the spindles so as to provide for drilling to any desired depth. In certain cases it is necessary to have the center holes the same distance apart, regardless of variations in the length of the work. For this purpose the adjustable stops are arranged

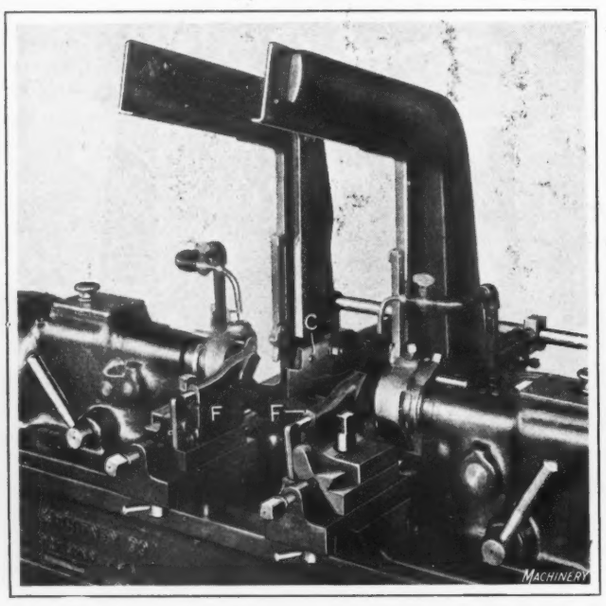


Fig. 3. Close-up View of One Transfer Plate and the Work Supports

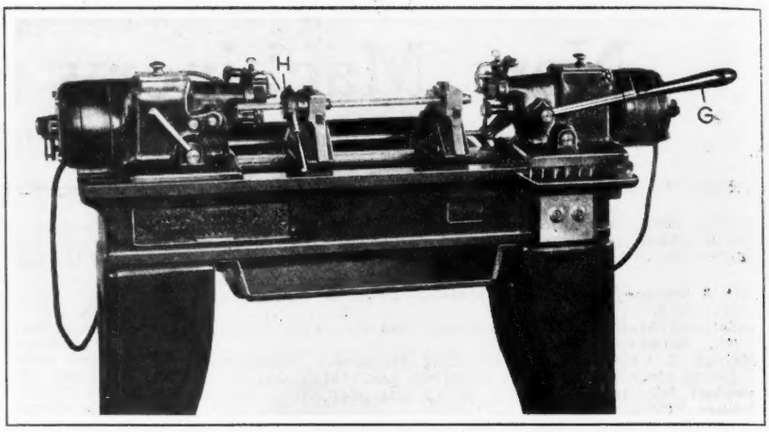


Fig. 4. Front View of the Hand-operated Machine equipped with Quick-acting Self-centering Vises

to engage lugs on the drill heads which hold the spindles to the predetermined forward movement.

During the centering operation, the work is supported by V-jaws *F*, Fig. 3, which have adjusting screws by means of which they may be set for work of different diameters. The jaws have an automatic arrangement which compensates for minor variations in diameter. The work is clamped in the jaws by the transfer slide plates *C*, Fig. 3, which remain in contact with the work during the drilling. Simple adjustments of the V-jaws make it possible to drill the hole out of center on one or both ends, when holes must be drilled in this way to receive driving pins for grinding operations, or when they are to serve as oil-holes. Facing or chamfering tools may be used on the machine in place of the drills. Different transfer plates for accommodating various diameters of work are easily mounted in place. Four sets of these plates cover the range of the machine.

Oil is supplied to the drills from a geared pump at the rear of the machine which runs at a constant speed. The tank is located under the bed, and the oil drains into it from all parts of the machine, including the work-box. The work-box is taken off for cleaning and for removing the finished parts. These are ejected from the V-jaws directly into the box, but when the latter is removed, a deflector hinged on the bed is latched in position to catch the work. The three motors are of ¼ horsepower, operate on 110- or 220-volt alternating or direct current, and run at a speed of 1700 revolutions per minute. A switch is supplied for controlling the starting and stopping of the motors. This machine receives work from 2½ to 18 inches in length and from ¼ to 1½ inches in diameter, as previously mentioned. It weighs about 1020 pounds.

The Hand-operated Machine

The hand-operated centering machine is also provided with two drill heads having individual motor drives, the spindles of which are simultaneously fed toward the work. However, the machine may be equipped with only one head in instances where the work is longer than can be handled with the duplex head. This machine can be quickly adjusted to suit work of all lengths and diameters within its capacity, and thus covers the requirements of a shop having a variety of work of the kind for which the machine is intended. The right-hand drill head is permanently attached to the bed, while the left-hand head can be moved along the bed to suit different lengths of work, and may be removed entirely for handling long work.

The drill spindles of the two heads are normally operated together by manipulating lever *G*, Fig. 4, on the right-hand head, the movement being transmitted to the left-hand head through the levers and a rod seen in Fig. 5. The drills are advanced by means of lever *G* until they contact with the ends of the work, which has been placed loosely between the jaws of the vise shown in Fig. 4, so that it may shift

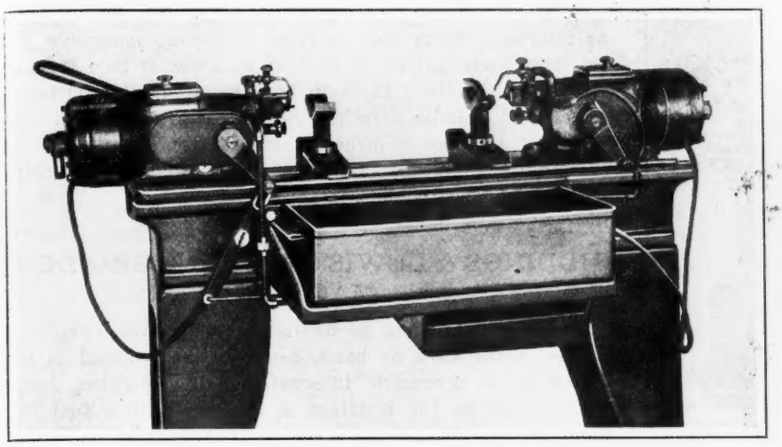


Fig. 5. Rear View of the Hand-operated Machine equipped with Adjustable V-supports

endwise during this step. When contact has been obtained, both jaws are tightened at the same time by operating lever *H*, after which the work is ready for centering. The drill spindles are mounted in sliding bronze sleeves and are provided with ball thrust bearings. The spindles can also be driven at speeds of either 1200 or 1800 revolutions per minute, the same as on the automatic machine. These tw speeds and locking of the spindles for the removal of drills are accomplished by means of a knob on the top of each drill head.

Other Details of Construction

As in the automatic centering machine, adjustable stops are provided on the heads to bear against the ends of the work so as to limit the forward movement of the spindles and hold the depth of drilling to the desired dimension. The center holes may be held the same distance apart by having the stops positioned to engage lugs on the drill heads. In Fig. 4 the machine is equipped with two quick-acting self-centering vises which take work of any diameter up to and including 2 inches. The vises are adjustable along the bed to accommodate work from 3 to 18 inches in length, and are operated simultaneously through lever *H*, as previously mentioned. However, for heavy work up to and including 4 inches in diameter, the adjustable V-supports shown mounted on the machine in Fig. 5 are used. Locking screws maintain the adjustment of these supports, and one of the supports has a clamping lever for holding the work in place.

After being centered, the work is deposited in a removable metal tote box at the rear of the machine. Oil is conveyed to the drills by means of a plunger pump, which is connected to hand-lever *G* and works in conjunction with it. By this arrangement, oil is supplied to the drills only while they are cutting, and this is accomplished without requiring attention on the part of the operator. Oil running from the work in the tote box is drained back into the supply tank. The drill-head motors on this machine are of the same type as those with which the automatic machine is equipped. An outboard support can be furnished for use in handling work over 5 feet long. The weight of this machine is approximately 600 pounds.

SUNDSTRAND STUB LATHE

The striking feature of the Sundstrand stub lathe is its unique construction. As will be seen from the illustrations, this machine is of an entirely different design from the ordinary lathe. Maximum rigidity has been obtained by making the headstock integral with the housing, which contains all the driving mechanism, exclusive of the motor, and on which the carriage ways are machined. It will be noticed that the tailstock is supported both by an over-arm and by a stud which extends from the bed. This machine has been primarily developed for turning automobile pistons, but it is also suitable for turning a large variety of parts, such as gears, pulleys, bushings, and automobile hubs and steering knuckles. It is built by the Rockford Tool Co., 2400 Eleventh St., Rockford, Ill.

The machine is driven by a 5-horsepower motor, which is fastened on a pivoted frame or plate in the bed, where it is entirely out of the way of the operator. The tension on the driving belt may be regulated through adjustment. The motor pulley is connected by belt to a friction-clutch pulley at the rear of the machine, as shown in Fig. 2. The upper pulley is mounted on roller bearings and the clutch is operated by means of the handle which projects from the front of the machine.

Details of the Spindle and the Feeding Mechanism

The spindle is driven through a worm and a heavy bronze worm-wheel, the reduction of which is in the ratio of 3 to 1. The worm is provided with ball bearings to eliminate friction. Through gearing, six spindle speeds ranging from 40 to 145 revolutions per minute are obtainable. The spindle is of generous proportions, and runs in phospher-bronze taper bearings which are lubricated by a wick feed from an oil reservoir provided with sight-feed oil-cups. Both bearings are adjustable by means of a nut at the rear of the spindle. Provision is made for mounting an air cylind and a quick-acting draw-back chuck on the spindle.

The feeding mechanism is driven from the spindle through a chain and pick-off gears located at the headstock end of the machine. The standard gears furnished provide for six feeds ranging from 0.020 to 0.090 inch per spindle revolution. The carriage and rear tool are fed through worm-gearing, the worm being submerged in oil. To start feeding, the worm is lifted into engagement with the worm-wheel by means of a handle located at the front of the machine. The worm-wheel is keyed on a pinion shaft which drives the carriage, and because of this construction no gearing is required in the apron. The large handwheel seen at the front of the machine is mounted on the worm-wheel and pinion shaft.

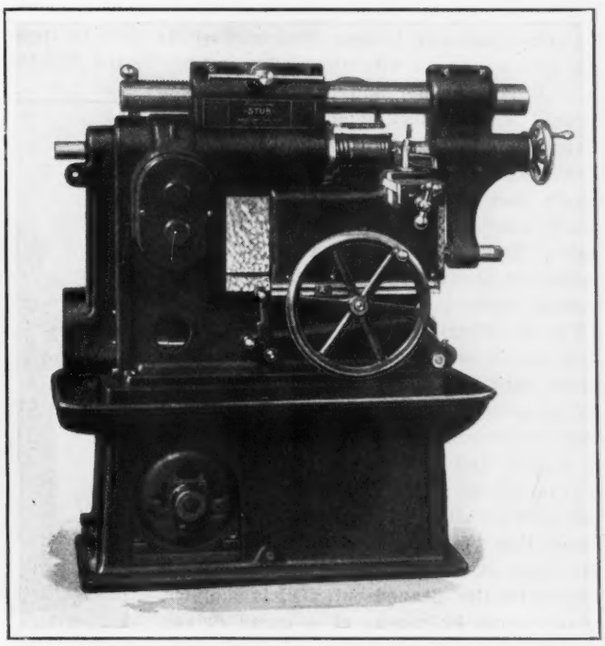


Fig. 1. Sundstrand Lathe of Unique Construction which was designed especially for turning Automobile Pistons

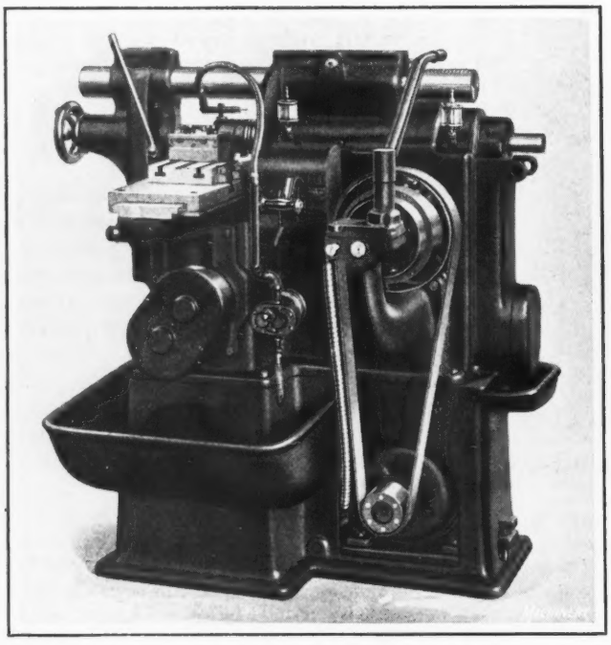


Fig. 2. Rear View of the Stub Lathe, showing the Driving Arrangement and the Rear Tool

The Carriage Construction

The carriage has a full-length bearing on an eight-inch face at the front of the housing and on a four-inch angular surface at the top. An angular gib is provided at the bottom of the carriage to take up wear. The front tool-slide has stop-screws underneath for tool adjustment, and the slide is of sufficient width so that several tools can be clamped on it at one time. The rear tool has a four-inch in and out travel and ample sidewise adjustment. The carriage feed can be ended at any desired point by setting a dog to trip the feed-lever and thus automatically disengage the worm of the feeding mechanism from its mating worm-wheel. This arrangement is said to be especially satisfactory when facing to close diameters or turning shoulders.

Method of Supporting the Tailstock

The tailstock is clamped to a large overhanging arm which extends from the headstock, and is also supported by means of a stud that projects from the main housing. This method of supporting and locking the tailstock is said to insure the elimination of vibration. The screw of the tailstock is of large diameter and has a lead of 1½ inches. The tailstock spindle is of sufficient diameter to withstand tendency to spring. The bearing for this spindle is split the full length and held in position with screws which may be adjusted to compensate for wear. This feature does away with any chance of the spindle becoming loose and causing chatter.

The overhanging arm is so arranged that tools can be clamped on it for several operations such as facing and boring the open end of pistons and center-drilling. Adjustment of the arm is easily effected by means of a rack and pinion, the rack being cut on the top of the overhanging arm. The bed is well ribbed throughout and so designed that the chips fall from the carriage into a pan at the back of the machine which may be readily cleaned out. Oil is supplied to the work by means of a pump driven directly from the main-drive friction pulley. A tank is located in the bed below the chip pan for the coolant.

Some of the principal specifications of this machine are as follows: Swing over carriage, 8 inches; maximum distance between centers, 12 inches; diameter of hole through headstock spindle, 1 13/32 inches; longitudinal adjustment of tailstock spindle, 5 inches; length of carriage, 18 inches; travel of carriage, 8 inches; distance from floor to center of spindles, 45 inches; and approximate weight of machine with motor, 3000 pounds.

GIDDINGS & LEWIS INTERNAL GRINDING MACHINE

An automatic gaging mechanism, which entirely eliminates gaging of the work by hand, has been incorporated in the design of an automatic internal grinding machine, lately brought out by the Giddings & Lewis Machine Tool Co., Fond du Lac, Wis. This machine is illustrated in Figs. 1 and 2. After the operator has chucked the work and started the feed, the machine will automatically grind the work to the finished size, trip the carriage at the end of the operation, and then return it to the starting position. This mechanism is of a construction that compensates for wear of the grinding wheel. Two gages are employed, one for the roughing and the other for the finishing feed.

When the roughing gage enters the work, the roughing feed is automatically ended, and the finishing feed is automatically engaged until the finishing gage enters the work, at which time the carriage is tripped as already mentioned. The two gages revolve at the work speed, and the finishing gage enters the work but once these provisions prolonging the life of the gages. The chief aims of the builders in designing this machine were to provide an equipment that would practically eliminate the requirement of skill on the part of the operator and that would automatically grind a hole to the desired size without resulting in the scrapping of parts.

The machine is motor-driven and is operated through a push-button control. The work-spindle is of large diameter, and runs in bronze bearings which are adjustable. There are six work-spindle speeds, which are selected by turning the handwheel on top of the work-head to any of six indicated positions. Ball bearings are supplied for the members that transmit power to the work-spindle. The work-head is mounted in a circular bearing on the cross-slide, and may be swiveled to permit the grinding of tapers having an included angle up to 30 degrees. The work-head can be indexed quickly and accurately to the required positions. A special three-jaw scroll chuck built by the Cushman

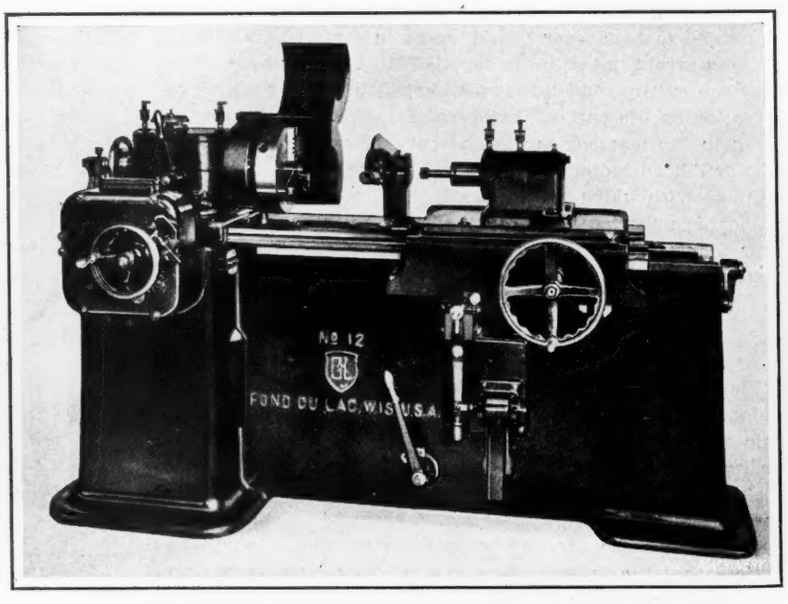


Fig. 1. Giddings & Lewis Automatic Internal Grinding Machine

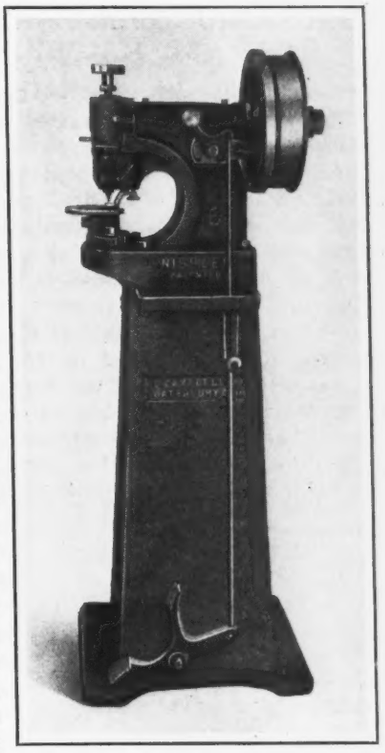
Chuck Co., and having a capacity for work from ¼ to 10¾ inches in diameter is furnished as standard equipment. This chuck is water-tight; all operating parts are protected against grit and the body is filled with grease. The body is made of steel and all working parts are hardened. A draw-bar is provided for opening and closing collet chucks, which is operated by the handwheel at the rear of the work-head.

The wheel carriage is heavily constructed and has large bearing surfaces on the vees of the bed. It is reciprocated hydraulically and, as the motor for driving the wheel-spindle is mounted directly beneath the carriage it reciprocates with it. The wheel-spindle is mounted on ball bearings in the head, the latter being tapered on the outside to suit the head housing, in which it is fastened by means of a lock-nut. This method of mounting the spindle permits of easy attachment and removal. A separate steel pulley is furnished with each wheel-spindle to provide for correct wheel speeds on all jobs. The work is fed against the wheel at each end of the stroke. Two separate series of feeds have been provided—ten roughing and five finishing feeds—which are controlled by the gaging mechanism, as previously outlined.

The bed of the machine is of substantial construction, being well ribbed to provide strength and rigidity. All bearing surfaces are amply protected from abrasive material. Water is supplied by a direct-driven centrifugal pump mounted within the machine, which forces the water through the center of the work-spindle to the work. Means have been provided for automatically shutting off the water when the wheel leaves the work, and for turning it on when the wheel enters the work. Some of the important specifications of the machine are as follows: Total swing over ways, 13 inches; range of hole diameter which may be ground, ¾ to 10 inches; maximum depth to which holes can be ground, 9 inches; maximum travel of wheel carriage, 20 inches; height of spindle from floor, 44 inches; and approximate weight of machine, 4400 pounds.

CAMPBELL NIBBLING MACHINE

Sheet metal up to and including 3/16 inch in thickness can be quickly cut to any desired outline by means of the patented nibbling machine here illustrated. This machine has a rapidly reciprocating punch of small size which enters a die held in the bedplate. The work is fed by hand against a stop-pin, so located as to allow a small part of stock to be removed by the punch on each stroke. This machine was exhibited by A. C. Campbell, Inc., Waterbury, Conn., at the recent machine tool exhibition held at Yale University.



Campbell Nibbling Machine for cutting out Sheet Metal

The design of the machine is such that sheet steel can be fed in any direction, and it can be cut out to the contour of superimposed templets in cases where the quantity of work is not sufficient to warrant making a blanking punch and die for use on a power press. The twelve punches furnished with the machine are easily inserted and removed from the holder. They are made from alloy steel, tempered and ground to size. Each punch is double-ended so that it can be reversed in the holder when one end becomes too worn for further use. An attachment enables circles to be cut conveniently up to 28 inches in diameter. This machine is especially adapted for cutting out stripper plates and gages for steel, malleable-iron, brass, or aluminum castings and steel forgings. Stock can be fed past the punch at an average rate of 18 inches per minute.

BROWN & SHARPE GROUND FORM GEAR-CUTTERS

Gear-cutters ground on the tooth form to correct hardening distortions and to align all teeth with the hole, have recently been placed on the market by the Brown & Sharpe Mfg. Co., Providence, R. I. The tooth form of these cutters is accurate within very close limits, and so the tooth spaces of the gears produced by using the cutters will be correspondingly accurate. Grinding of the tooth form is said to give a positive method of controlling the form of different cutters, and of obtaining duplicates. This ability to obtain duplicate cutters is of importance to gear manufacturers who especially desire uniformity.

The aligning of the teeth gives the cutters a free cutting action, which is largely due to the fact that each tooth does its share of the work. Faster feeds have been used with these cutters than with ordinary cutters, and it is claimed that more gears have been produced between resharpenings. The longer wearing qualities are said to be due to the even distribution of the work of cutting among all the teeth, so that the resulting heat is not confined to any one part of the cutter. This eliminates localized heating, which is one of the common causes of cutter wear. Another factor that adds to the life of the cutters is that a positive clearance is given to the teeth which eliminates rubbing of the form back of the cutting edge. These cutters can be supplied in sizes of from 1¾ to 12 diametral pitch, inclusive.

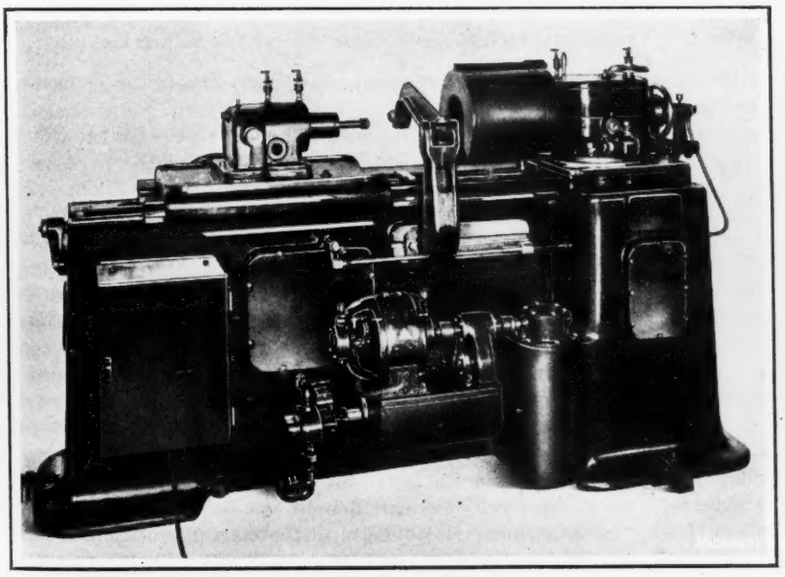


Fig. 2. Rear View of the Automatic Internal Grinding Machine showing the Arrangement of the Motor Drive

BAUSH MULTIPLE-SPINDLE DRILLING MACHINE

Feeding of the drill head on the new multiple-spindle drilling machine built by the Baush Machine Tool Co., Springfield, Mass., is accomplished by means of a ram located at the center of the head so that the pressure is applied at the center of the drilling area. The main advantages claimed for this construction are a true alignment of the drill spindles and the elimination of head binding. Power for driving the spindles is transmitted to the gears of the drill head through a vertical shaft at the front of the column. Another feature of the machine is the quick approach of the drill head to the point where the drills are about to contact with the work and the quick return to the starting position when an operation has been completed. These fast forward and return movements are made possible by the use of friction clutches in the change-feed gear-box. No damage results if the drills come in contact with the work when fed at the fast rate, because the friction clutches will slip and thus stop the downward movement of the head. The fast return of the head is automatic.

The machine as illustrated is arranged for being driven by belt through a three-speed gear-box, but it may also be driven by belt through a three-speed cone pulley, by motor through a three-speed gear-box, or by a direct-connected variable speed motor. The feed ram is raised and lowered by a pinion meshing with a rack on the ram, this pinion being driven through the change-feed gear-box mounted on top of the column. For each change of speed, there are three feed changes, which makes nine rates of feed in all, varying from 0.0018 to 0.023 inch per spindle revolution. The feeds mentioned are standard, but faster or slower feeds may be provided to suit requirements.

Either round or rectangular heads can be furnished in a number of sizes. The head is equipped with the patented spindle arms which are in use on all Baush drilling machines. These arms allow a liberal vertical adjustment of the spindles and permit a center distance as short as the diameter of the spindle itself. The universal joints are also of the type used on Baush multiple-spindle drilling machines. The drill head has an automatic safety catch, which prevents the counterweight from falling in case of an accident to the cable. Owing to the head feeding arrangement, the distance from the center of the head to the face of the column is made considerably greater than is customary when the head is fed directly from the column.

Except in counterboring, the head is operated by hand only in an emergency and for adjusting tools to height and to align with jigs. For this reason the pilot wheel for hand-feeding is located at one side and is disconnected when not in use. The column has a hole at the back through which weights may be added or removed from the counterweight for adjusting the balance of the head. Tripping of the head may be accomplished at any desired point by means of an automatic mechanism. The bed has T-slots in it, and either a box or rotating table may be mounted on it. An oil-pump and oil-tubes are furnished when desired. The bed has grooves and a reservoir for collecting the coolant.

A counterboring attachment adjacent to the pinion which feeds the head ram, provides for advancing the head very slowly by hand. This is convenient in spot-facing and similar operations. Back-gears in the head may also be employed to reduce the spindle speed in such an instance. The machine is also built for tapping in addition to drilling. In the tapping model, back gears in the head are used to reduce the spindle speed, and these gears can be engaged or disengaged while the machine is running. In tapping, the operator brings the taps down to the work by means of the quick approach, after which a further downward movement of the head is controlled by the lead of the taps. At a certain point the direction of the rotation is automatically reversed and after the taps have cleared themselves from the work, the operator throws in the quick return. The head then rises quickly to the starting position, where it stops, and at the same time the rotation of the spindles is automatically reversed for the next operation.

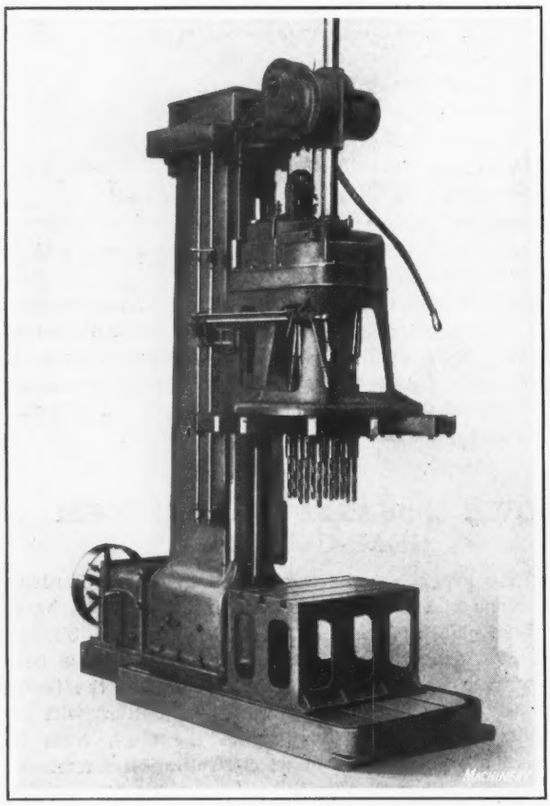


Fig. 1. Baush High-speed Multiple-spindle Drilling Machine

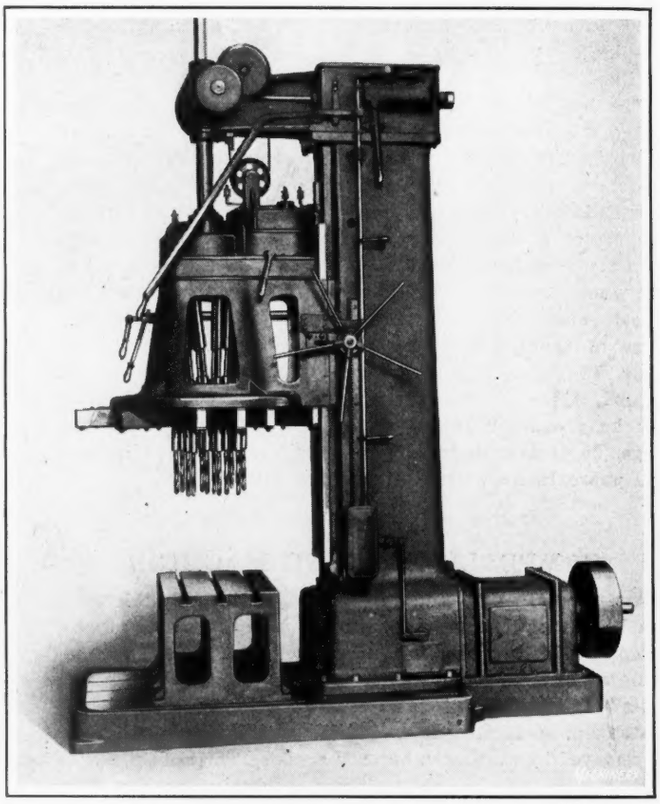


Fig. 2. The Multiple-spindle Drilling Machine from the Left-hand Side

Some of the important specifications of the machine are as follows: Maximum and minimum distance of spindles from bed, 45 and 20 inches, respectively; distance from center of head to face of column, 20 inches; total traverse of head, 25 inches; horsepower required for driving the machine, from 15 to 20. The machine has a capacity for drilling twelve 1-inch holes simultaneously through cast iron.

WILLIAMS CYLINDER GRINDER

One of the important points in grinding machine design is to provide against the likelihood of the abrasive dust working into bearings or between sliding surfaces. This has been taken care of in the construction of the Williams cylinder grinding machine, illustrated in Figs. 1 and 2.

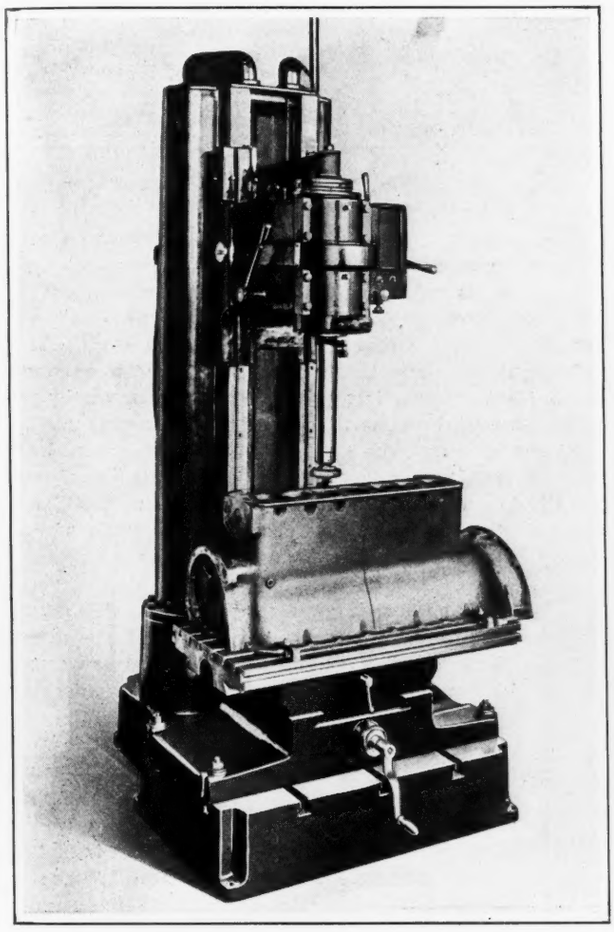


Fig. 1. Williams Vertical-spindle Cylinder Grinding Machine

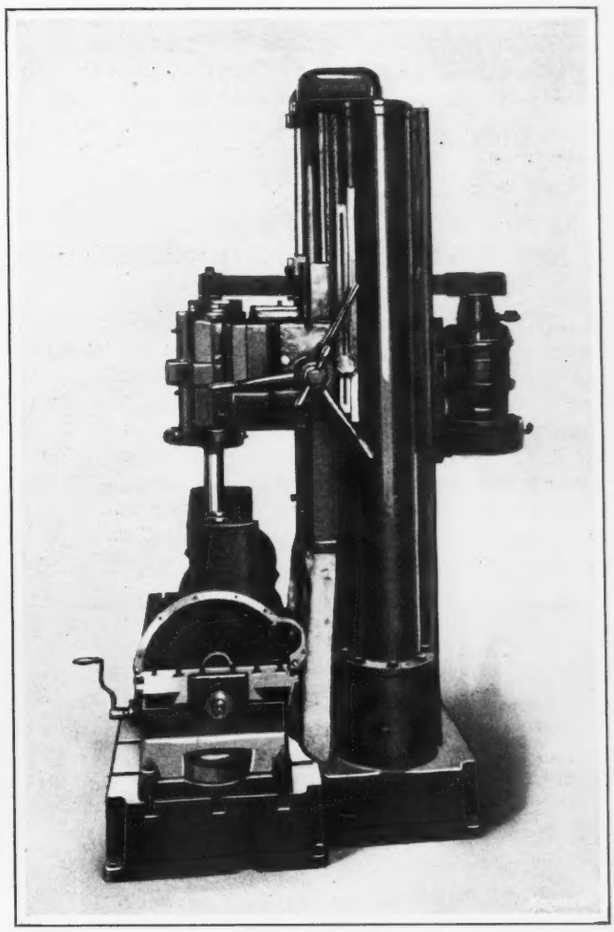


Fig. 2. View of Cylinder Grinding Machine from Right-hand Side

by placing the grinding wheel spindle in a vertical position and locating the entire driving mechanism of the machine above the wheel. Because of this arrangement, the abrasive dust falls through the cylinder being ground, and is not carried to bearings or sliding surfaces. The ways of the column on which the carriage moves are protected by a canvas curtain. Similarly, the longitudinal slide of the table has a sufficient movement from the center of the column in both directions to permit grinding three cylinders each way, without uncovering the ways of the slide. This machine is being placed on the market by the Hy-Way Service Co., 225 S. St. Joseph St., South Bend, Ind., and is intended for both automobile manufacturing plants and service stations.

In setting up the machine for grinding any given size of cylinder, the correct transverse positioning of the cylinder under the grinding wheel is accomplished by means of the cross-slide controlled by turning the crank at the front of the machine. The entire driving mechanism is carried by the wheel-head, including the two-horsepower motor mounted at the back of the head. Three functions are performed by the power derived from this motor: (1) It rotates the wheel-spindle; (2) it actuates a planetary motion to the spindle unit; and (3) it feeds the head downward to advance the grinding wheel into the cylinder being ground, and also returns the head to the starting point.

The Grinding Wheel Spindle Drive and Planetary Rotation

The motor drives from both ends, through a pulley at the upper end and through spiral gearing at the lower end. The pulley transmits power direct to the grinding spindle through a fabric belt. In this way the high speed of the motor is utilized to give the required speed for the abrasive wheel. The correct speeds for the various sized wheels which are employed, are obtained through the use of different diameter pulleys on both the motor shaft and the grinding spindle.

The grinding spindle is mounted in a sleeve which, in turn, is eccentrically located in a second sleeve. There is a ring bevel gear on the second sleeve to which power is transmitted for rotating the entire wheel unit independently of the spindle rotation. The two sleeves are arranged in such a way that, by making adjustments, the grinding spindle may be set eccentrically any amount from 0 up to 1⅛ inches, to obtain the desired planetary rotation. This amount of adjustment is ample for the grinding of all commercial sizes of automotive cylinders. A graduated dial indicates the amount of eccentricity for which the unit is set.

The spiral pinion at the lower end of the motor shaft transmits power for the planetary movement through spiral, bevel, and spur gears to a pinion that meshes with the ring bevel gear on the second sleeve. Two different speeds of planetary rotation are obtained by manipulating the lever

on the left-hand side of the spindle head, which controls a clutch.

The Feed and Return Movements

There are sixteen rates of feed ranging from 0.007 to 0.375 inch per spindle revolution, for advancing the wheel into the work. These feeds may be selected by manipulating plungers and a lever on the change-feed gear-box. After the grinding wheel has been lowered to the desired point, the feed is reversed to carry the wheel-head back to the starting position. This reversal of movement is automatically accomplished by means of stops on the column which trip a clutch. There is also a small plunger on the change-feed gear-box, which may be manipulated by hand to cause a reversal in the direction of the wheel-head movement.

It will be apparent from Fig. 1 that feeding of the head up and down on the column of the machine is accomplished through pinions which mesh with two racks. The capstan wheel at the right-hand side of the head provides for raising and lowering the head by hand, in addition to the power feed and return. The wheel-head is balanced by counterweights so that it may be easily moved. The mechanism of the change-feed gear-box runs in a bath of oil to insure efficient operation without undue wear.

KELLER AUTOMATIC DIE-SINKING MACHINE

One of the attractions of more than passing interest at the exposition of the American Society for Steel Treating held in Detroit during the early part of last month, was the Type F automatic die-sinking machine exhibited by the Keller Mechanical Engraving Co., 74 Washington St., Brooklyn, N. Y. This machine was shown in actual operation on an automobile crankshaft die and on a core-box for an automobile intake manifold. The machine is especially adapted for making forming, stamping, and forging dies. It is intended for work up to 36 inches in length and 20 inches in width, being intermediate between two other sizes built by this firm. It cuts to a depth of 8 inches.

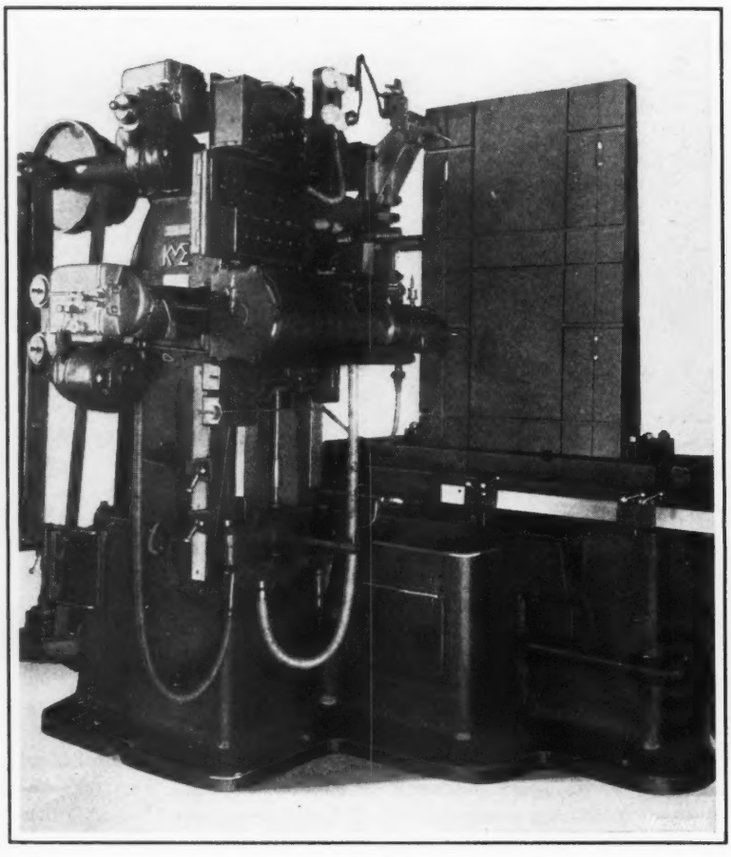


Fig. 1. Keller Type F Automatic Die-sinking Machine

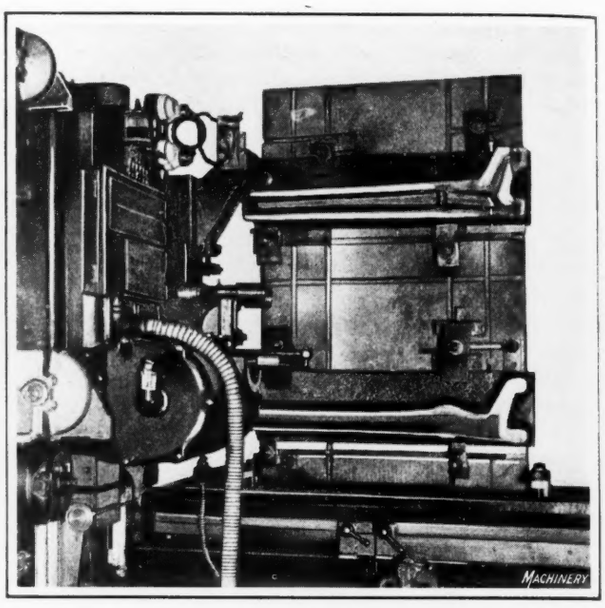


Fig. 2. The Automatic Die-sinking Machine engaged in an Operation on a Die

The cutter is guided over the work and in and out by means of a tracer point which follows the outline and contour of a master placed directly above the work. This master may be made either of plaster, cement, or wood. Only a slight pressure is exerted against the master by the tracer, while at the same time sufficient pressure is applied to the cutting tool. The entire machine is controlled by a group of push-buttons, and it may be operated semi-automatically in addition to its automatic operation. Rectilinear motions in three directions are provided, these motions being obtained by means of lead-screws which operate the different slides. Automatic feeds are provided both vertically and horizontally and there is a quick return in both directions for the horizontal movement. There is also a contouring or profiling movement by means of which a templet, or the ridges or grooves of a master, may be followed.

When the work leaves the machine, it is in a condition that necessitates a minimum amount of hand work for finishing. In the case of dies and punches for sheet-metal work, most of the labor ordinarily required for fitting is eliminated, because even the allowance for stock thickness may be provided for in the master. The spindle head is carried on a wide vertical slide, the movement of which is controlled electrically. All slides are provided with taper gibs. There are two spindles, one slow-speed and one high-speed, and adjustments are provided on both to compensate for wear. The spindles are driven by a separate motor, direct-connected to a lower cone-pulley shaft at the rear of the column. The low-speed spindle is driven through a pulley which is connected by belt to the corresponding upper cone-pulley shaft.

Two interchangeable pulleys, 4 and 6 inches in diameter, respectively, are supplied. The low-speed spindle pulley with back-gears is mounted as a complete unit on the spindle head, and the high-speed spindle is driven from the low-speed spindle pulley shaft through a grooved pulley. There are eight speeds for the low-speed spindle through the back-gears, ranging from 80 to 324 revolutions per minute, and eight speeds through the open belt, ranging from 298 to 1212 revolu-

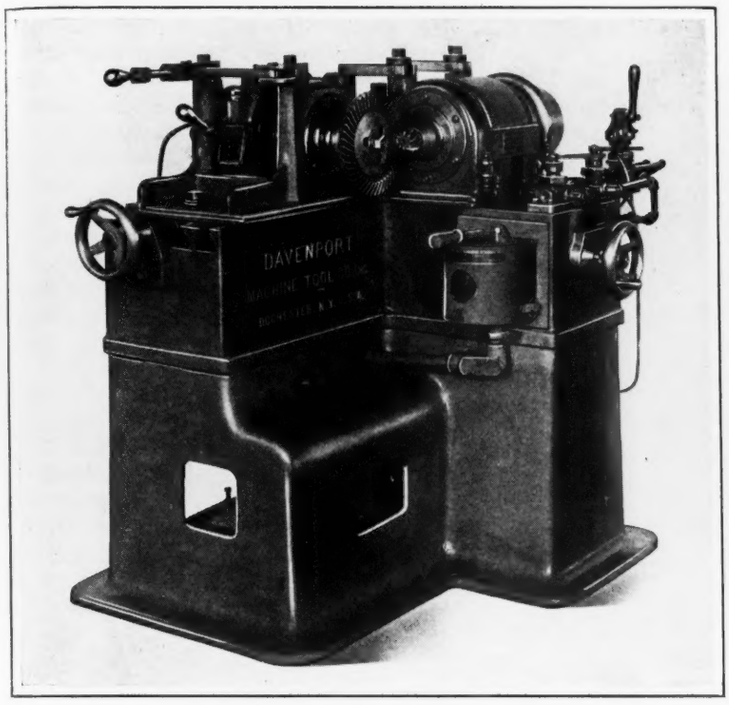


Fig. 1. Davenport Machine for testing Spiral-bevel Gears of All Sizes used in Automobiles

tions per minute, making sixteen speeds in all. There are also eight speeds for the high-speed spindle ranging from 894 to 3636 revolutions per minute. The spindles and their slide are lubricated from a sight-feed oil-cup, while the cutter receives lubricant from a gear-driven pump.

The control cabinet is a separate unit connected to the machine by wiring contained in a flexible conduit. The cabinet contains the main switches, motor starters, reversing switches, relays, drum controller, and motor-generator set. A series of push-buttons provides hand control for all movements of the machine. Some of the important dimensions of this die-sinker are as follows: Working surface of table, 53 by 22 inches; horizontal travel of table, 36 inches; speeds of table, from 1½ to 12 inches per minute; travel of vertical slide, 20 inches; feeding rate of vertical slide, from 0.010 to 0.830 inch per stroke; in and out movement of spindle head, 8 inches; floor space required, 9 by 8 feet; and height, about 6 feet 8 inches.

DAVENPORT SPIRAL-BEVEL GEAR TESTING MACHINE

Spiral bevel gears of all sizes used in automobiles may be tested by means of the machine illustrated, for bearing of the teeth, quiet running, and to determine the center distance at which mating gears run with the best bearing of the teeth and the least noise. This machine has just been brought out by the Davenport Machine Tool Co., 167 Ames St., Rochester, N. Y. The two gears to be tested are each mounted on the end of a spindle in headstocks placed at right angles to each other. Each headstock may be moved at right angles to its spindle through a dovetailed slide, which is provided with a taper gib. The headstocks have large bearing surfaces on the bed, and they may be clamped to these surfaces by bolts projecting from T-slots in the bed.

Inasmuch as there is usually but little adjustment required of the left-hand headstock, that is, the one on which the crown gear is mounted, this headstock is clamped to the bed by operating a lever attached to one of the holding-down bolts and having an adjustable connection to the second bolt. This arrangement permits quick tightening of the two bolts at the same time. The right-hand headstock, however, is moved quite a distance each time a gear or pinion is changed for testing, and because of this, provision has been made for quickly operating this headstock through the use of air pressure. A pneumatic cylinder is mounted on the back of the machine, as shown in Fig. 2, for this purpose.

After the slide has been drawn back a fixed distance and the pinion has been changed, the new pinion may be brought into mesh with the crown gear at exactly the same position as that in which the preceding pinion was tested or at any other position. The positioning of the pinion is controlled by the handwheel located underneath the right-hand headstock. This handwheel is provided with a graduated dial. Owing to the fact that the right-hand headstock is moved frequently, provision is also made for clamping it pneumatically. In addition to these time-saving arrangements, the machine is equipped with an air chuck to permit quick clamping of the pinion to be tested.

It will be seen from Fig. 1 that three air valves are located at the front of the machine. One of these valves is operated to clamp the work on the spindle, the second to slide the headstock forward to bring the pinion into mesh with the crown gear, and the third to clamp the headstock in the testing position. Reversal of these valve handles in the proper sequence will result in unclamping the headstock, moving the slide back to facilitate changing the pinion, and unclamping the pinion. Both headstock spindles have large Hess-Bright ball bearings at each end, and these are so arranged that the oil in the bearings is always kept at a certain height. The headstock spindles may be rotated in either a clockwise or a counter-clockwise direction. The machine is driven by a 3-horsepower alternating- or direct-current motor. The motor is mounted inside the base, and is so connected up that the correct tension is kept on the belt as the right-hand head-

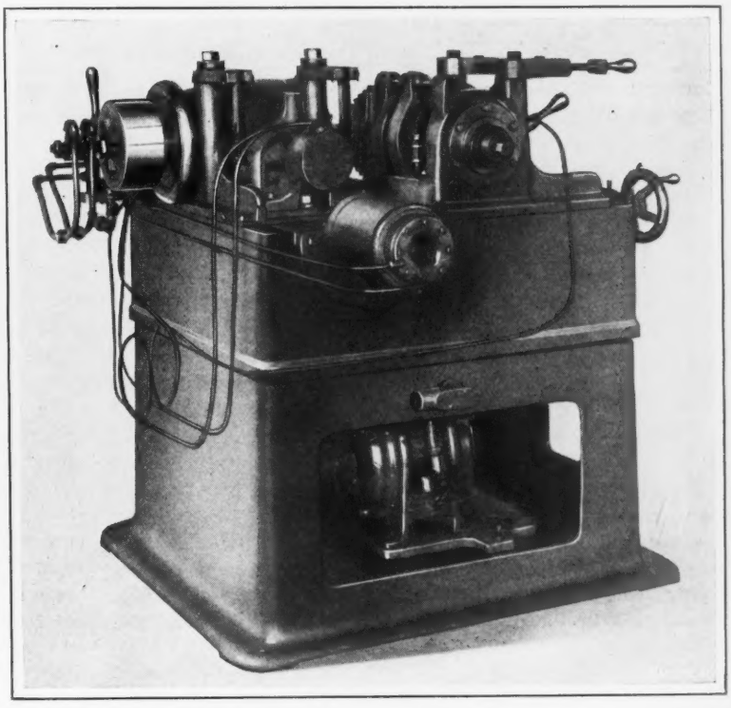


Fig. 2. View of the Gear Testing Machine showing the Location of the Motor and the Headstock Air Cylinder

stock slides back and forth. The exhaust from the air cylinder is piped to a brake band on the crown-gear headstock to cool the brake; however, water may also be circulated through the braking members for that purpose. The machine occupies a floor space four feet square, and weighs approximately 1500 pounds.

HOLMES TILTED THREADING MACHINE

Cap-screws, king bolts, spring clips, and similar parts, when produced in large quantities, can be threaded at high production rates by employing the six-spindle "tilted threader No. 3" shown in Figs. 1 and 2. This machine is a recent product of the Holmes Engineering Co., Oshkosh, Wis. By making a few additions and substitutions, the machine may also be arranged for tapping a large variety of parts, such as automobile steering-arm yokes and turnbuckles. The six spindles are placed at an angle of 30 degrees with the vertical, which prevents chips lodging in the self-opening die-heads and permits the use of self-

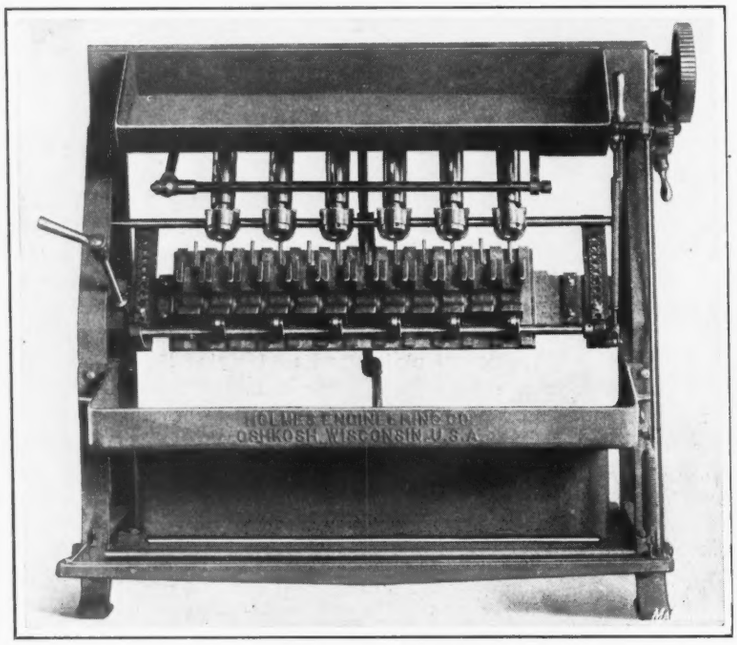


Fig. 1. Holmes Tilted Threading and Tapping Machine

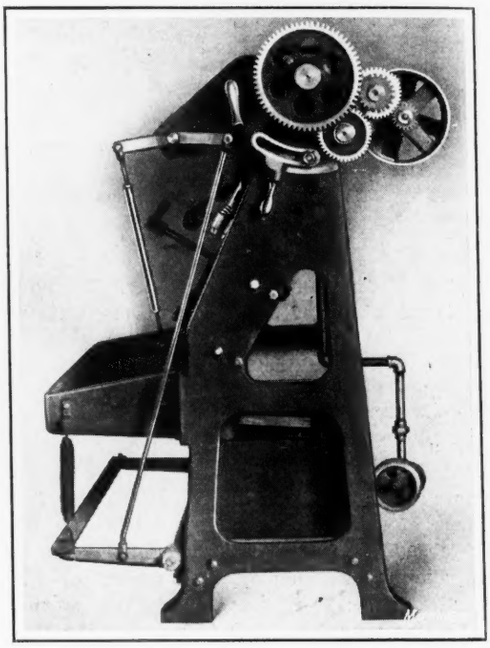


Fig. 2. End View of the Machine shown in Fig. 1

clamping work-holding jigs. Twelve jigs are used, and these are fed in pairs of six to the die-heads, during which time the other six idle jigs are reloaded. A foot-treadle is used to bring the jigs to the die-heads, and thus the operator is able to employ both hands in reloading.

The jigs are mounted on a carriage which is slid either to the right or the left, as the case may necessitate, at the end of a threading operation, in order to bring the new pieces of work in the previously idle jigs, into alignment with the die-heads. The jigs are fed through the medium of rollers which are swiveled with the shaft running the length of the machine along the back of the jigs. This shaft is given a rotary movement when the foot-treadle is depressed. When the pieces have been sufficiently engaged by the die-heads, the jigs are pulled forward by them until the die-heads are opened, at which time the jigs, by their own weight, fall back into a neutral position. The handling of long and short work is provided for by two brackets one at each end of the roller shaft, which support this shaft. These brackets have a series of holes that permit a variation in the distance between the die-heads and the roller shaft.

Four changes of speed are obtainable through change-pinions, and right- and left-hand threads can be cut. Lubricant is supplied to each die-head from a rotary pump through individual pipes. Bronze bearings are used throughout, and all thrust points are relieved by grooved ball races. A work shelf, large enough to accommodate two tote boxes, is located just above the spindles. The inclination of this shelf brings the parts to be machined within easy reach of the operator. The machine has a threading capacity up to 1-inch U. S. standard or 1¼-inch S. A. E. standard threads.

When arranged for tapping, the taps are held in spring collets, and an attachment is added to the top of the machine. The taps are automatically reversed and returned at twice the cutting speed, whether cutting right- or left-hand threads. This reversal may be made at any depth of tapping. The machine taps threads up to ¾-inch U. S. standard or 1-inch S. A. E. The production on externally threaded work is from 1200 to 2000 pieces per hour, and on tapped holes, from 1000 to 1500 pieces per hour.

BAIRD SIX-SPINDLE CHUCKING MACHINE

Castings, forgings, and cut-off bar stock pieces which can be held in a chuck while being machined may have a number of operations such as turning, facing, chamfering, drilling, boring, reaming, and threading, performed simultaneously on five pieces by employing a six-spindle chucking machine now being introduced to the trade by the Baird Machine Co., Stratford Ave., Bridgeport, Conn. The machine handles work up to 6 inches in diameter by 6 inches in length, and might be classified as an "automatic lathe for short pieces." The pieces of work are held by chucks on a turret which indexes to bring each piece successively into position for being operated upon by each set of tools. One piece is finished per turret revolution. The finished part is replaced by an unfinished part, when it reaches the idle position at the front of the machine.

As the finished part reaches this position, the machine automatically stops, so that inattention on the part of the operator will not result in the work going twice through the cycle of operations. However, the machine need not stop for replacing the finished work, and so it can be set to run without stopping, on jobs where it might be more economical to have that arrangement. As many as fifteen tools can be mounted on the main tool carriage, which is fed forward to the work, and three tools can also be held on each of the two cross-slides at the front and rear of the machine, making a total of twenty-one tools which can be employed on the machine at one time.

The machine is driven through a single pulley, and when this pulley is run at a speed of 800 revolutions per minute,

the minimum spindle speed obtained through the medium of sliding gears, shifted by means of hand-levers on the housing near the pulley end of the machine, is 28½ revolutions per minute, while the maximum speed is 440 revolutions per minute. Spindle speeds between the minimum and maximum limits are obtained through eight possible combinations of the gears and three of the spindles, thus giving a total of twenty-four speeds. By means of this arrangement, the different spindles may at any time be revolved at three speeds. For example, if it should be required that one spindle operate at twenty revolutions per minute, each of the four remaining spindles might be operated at a speed of either twenty, thirty or forty revolutions per minute.

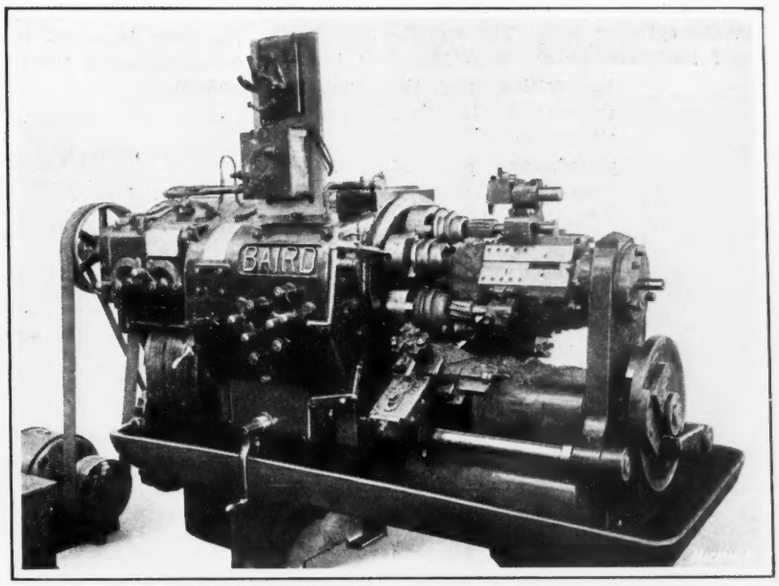


Fig. 1. Baird Chucking Machine for machining Small Castings, Forgings, etc.

There are seventeen feeds for the tools, which are also quickly obtained through hand-levers on the main housing. The minimum production rate with the driving pulley running at 800 revolutions per minute is one piece every nine minutes, and the maximum rate is 2 2/3 pieces per minute. The spindle speeds and tool feeds are selected to give the maximum production for the particular job; thus a hole of small diameter can be bored at high rates of speed and feed, while at the same time the outside surface can be turned at the best feed and speed for that operation. The spindles may be adjusted independently to suit conditions. Each spindle is driven through a clutch which is disengaged during the indexing movements of the work-holding turret. The chucks may be replaced by special fixtures when necessary.

The main tool carriage has a separate slide for each station of the turret, and there is always a choice of two lengths of feed for the slides. The tool-holders are interchangeable. During the setting of a machine for a given job, the relation of the various movements may be determined by turning a hand-crank, which may be employed at either the front or rear of the machine. All operating levers are located at the front to afford a convenient control. Lubricant is supplied to the work by a power-driven pump. The machine occupies a floor space of about 8 by 4 feet, and weighs approximately 8500 pounds. When the machine is motor-driven, a motor of five horsepower is required.

BEARD INSIDE MICROMETER AND HEIGHT GAGE

A self-aligning and centering inside micrometer and height gage is being placed on the market by the L. O. Beard Tool Co., Lancaster, Pa. This instrument is especially applicable for determining the diameter of automobile cylinder bores. As shown in the illustration, the micrometer is held in the bushing of an aligning base, which can be moved along the walls of a cylinder by means of a wire handle. The micrometer body is a sliding fit in the bushing, thus permitting adjustment to be made for determining the diameter of different sized holes. The fit is such that the base can be slid forward on the micrometer body after a reading, so that the instrument can be tilted to facilitate its removal from a hole without altering the setting. After the micrometer has been placed in a cylinder, the mechanic bears down on the aligning base to cause the tool to center itself accurately. The spindle is then

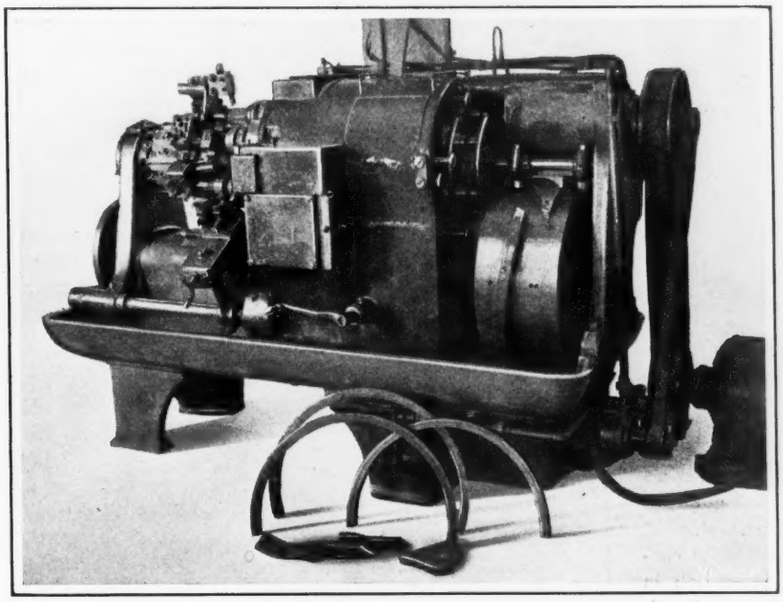


Fig. 2. Rear View of the Baird Six-spindle Chucking Machine for Lathe Operations, shown in Fig. 1

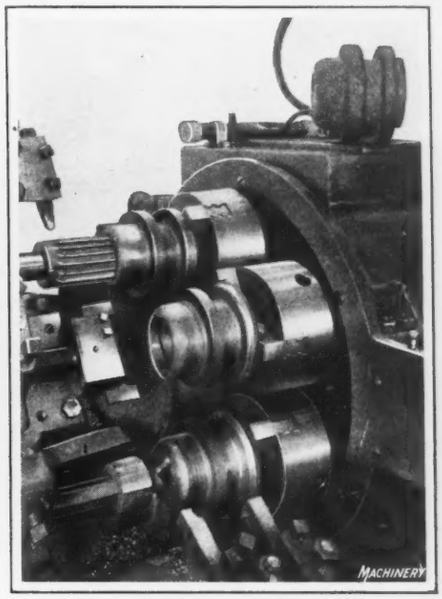
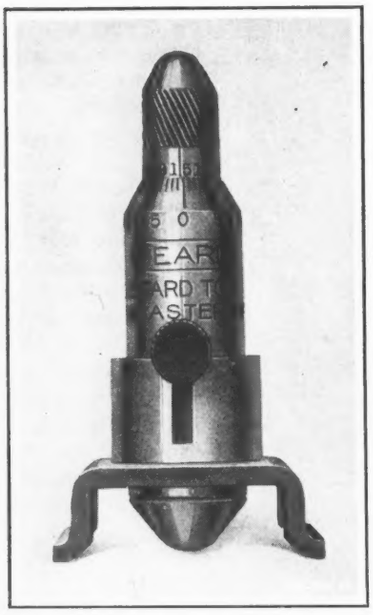


Fig. 3. Close-up View of the Work-holding Turret

screwed out by turning the knurled end until the point opposite the base touches the cylinder wall. The spindle is next locked by means of the clamping screw to retain the setting, and the instrument is then tilted, as previously stated, and removed from the cylinder.

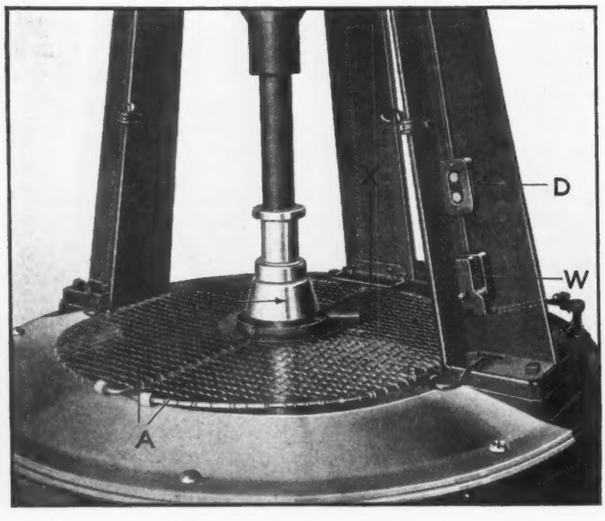


Beard Self-aligning Inside Micrometer and Height Gage

The micrometer gives a direct reading in thousandths of an inch, one complete revolution of the spindle causing the screw to move 0.050 inch. The reading is always given at two different places as a check. For instance, when 25 on the spindle is in line with 0 on the barrel, if the micrometer is turned half way around, the figures will be found to be reversed, that is, 25 on the barrel will be in line with 0 on the spindle. A ring at the bottom of the micrometer prevents it from dropping out of the base while in use. Both ends of the micrometer and the parallel edges of the base are hardened and ground.

TOLHURST CENTRIFUGAL EXTRACTOR GUARD

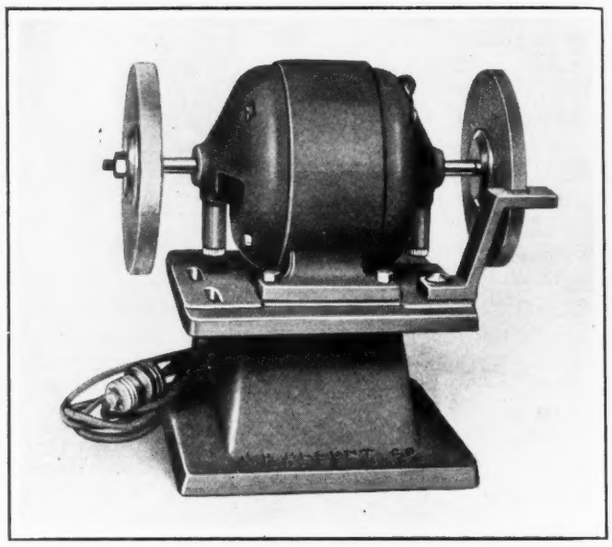
Centrifugal extractors, built by the Tolhurst Machine Works, Troy, N. Y., may now be equipped with a guard which is so interlocked with the driving mechanism of the machine that power cannot be applied until the guard is completely closed. It is also impossible to open the guard while the machine is in operation. This guard is applicable to both belt- and motor-driven extractors. The accompanying illustration shows the installation of a guard on a motor-driven machine, which is started and stopped by means of the push-button switch *D*. Interlock *W* is connected with loop *X* in such a manner that the switch is inoperative until the guard sections *A* are completely closed. Consequently the motor cannot be started before the guards are closed. Lock *U* prevents opening of the guard until the basket has come to a full stop. It will be seen that this lock is so small that it offers no interference to the reloading of the basket.



Wire Safety Guard for Tolhurst Centrifugal Extractors

BLOUNT COMBINATION GRINDER AND BUFFER

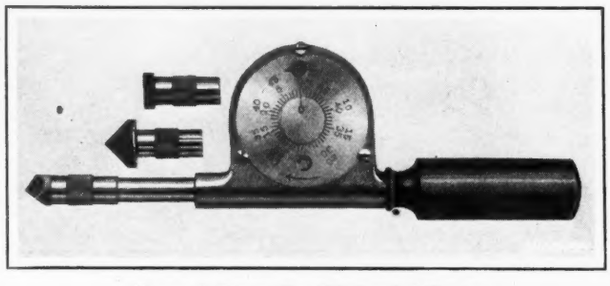
For grinding tools, smoothing small castings and numerous other applications in machine and repair shops, garages, etc., the J. G. Blount Co., Everett, Mass., is introducing to the trade a small plain-bearing motor-driven combination grinder and buffer. This machine is built for operation by either alternating or direct current. It is equipped with a Westinghouse ¼-horsepower motor running at a speed of 1800 revolutions per minute. The wheel flanges are machined all over to insure balance. Guards may be furnished for both sides for use with grinding wheels, and two toolrests may also be supplied. A pan supports the guards and the rests. The buffing wheel shown on the left-hand side of the motor is 7 inches in diameter by ⅜ inch thick, while the grinding wheel is 6 inches in diameter by ½ inch thick.



Blount ¼-horsepower Combination Grinder and Buffer

BROWN & SHARPE SPEED INDICATOR

An indicator which registers up to 5000 revolutions in increments of five revolutions, although speeds in excess of 5000 revolutions per minute may be determined, has been brought out by the Brown & Sharpe Mfg. Co., Providence, R. I. This indicator accurately determines the speed of shafts rotating in either direction, and measures high and low speeds equally well. Readings are taken from one side, the two arrows on the face of the dial indicating which figures to use for the two directions of rotation and thus eliminating confusion. The figures appearing at the small holes of the dial each show five revolutions direct, and the

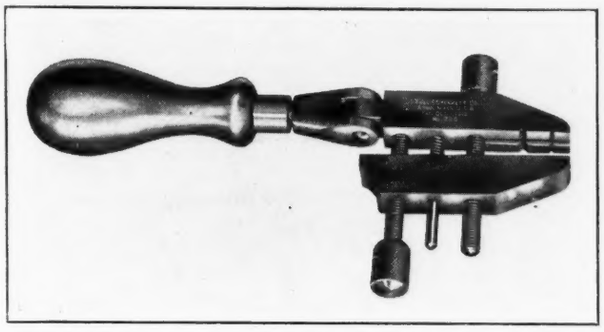


Brown & Sharpe No. 748 Speed Indicator

small inside dial indicates every 100 revolutions. This dial is quickly turned to zero for repeated use by means of a knurled knob on the back of the instrument. Three contact points are furnished—a steel point for ordinary speeds, and rubber points for high speeds. The fiber handle provides an insulation against electricity.

STARRETT HAND VISE

For holding small work conveniently in speed lathes and under drilling machine spindles while performing such operations as lapping or drilling, the L. S. Starrett Co., Athol, Mass., is placing on the market the hand vise shown in the accompanying illustration. This vise will hold work up to 1 inch in diameter or thickness, and the depth from the end of the jaw to the first screw is 1⅛ inches. Three V-grooves facilitate the clamping of round work. The

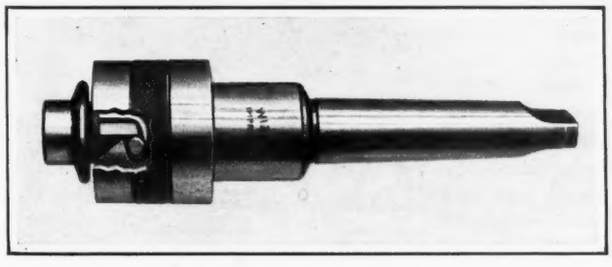


Starrett Vise for holding Work in a Speed Lathe or Drilling Machine

handle may be adjusted to any position within 180 degrees, which is a feature that is of importance in many applications of the vise. A spring and rod prevent the adjustable jaw from dropping or sliding when the clamp is being opened or closed. The over-all length of the vise is 7½ inches, and its weight is 12 ounces. All the steel parts are casehardened.

McCROSKY QUICK-CHANGE DRILL CHUCK

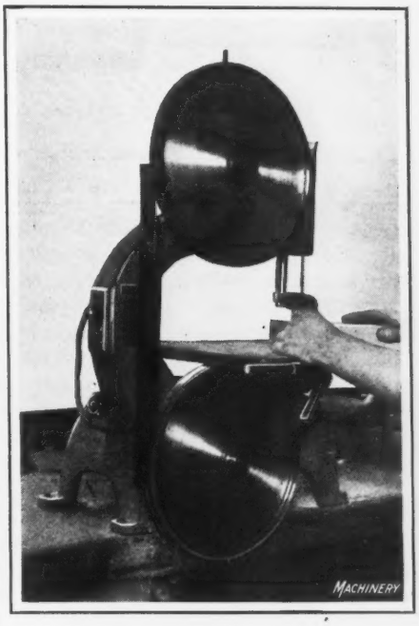
Easier operation of the "Wizard" quick-change drill chuck manufactured by the McCrosky Tool Corporation, Meadville, Pa., has been made possible by a number of improvements recently incorporated in its design. The chuck consists of two main parts, a driving body having a Morse taper shank for fitting into the socket of drilling machine spindles, and a collar for holding the collet in the driving body. Bayonet locking slots in the collar admit driving lugs on the collet, the design being such that the collet can be inserted or released with one hand without stopping or slowing up the rotation of the machine spindle. To insert a tool, the operator merely pushes the collet into the revolving body, and to release it he presses slightly on the knurled collar with his thumb and forefinger. The illustration shows the collet locked in place. The collar is hardened all over and is made straight to facilitate handling.



"Wizard" Quick-change Drill Chuck of Improved Design

JARVIS BENCH BAND SAW

A band saw intended for general application in pattern shops and manual training schools is here illustrated. This band saw is manufactured by Benjamin E. Jarvis, Inc., 113 Mechanic St., Newark, N. J. It may be bolted to a bench or left fastened to the bottom of the crate in which it is shipped, for portable use. The machine is supported by a one-piece cored casting which is designed to minimize vibration. The wheels over which the band saw runs are 12 inches in diameter, and have a 1-inch face. They are each made from two steel disks, riveted together, and are mounted on ball bearings. The band saw is furnished with top and bottom roller guides, which revolve on hardened centers.



Jarvis Bench Band Saw, which is also adapted for Portable Use

Current for driving the ¼-horsepower motor may be supplied from any electric light socket. The motor is started and stopped by means of a push-button switch located on the machine frame. The table is 13½ inches wide, 15 inches long, and may be tilted to any desired angle. The machine is designed to handle stock up to 2 inches in thickness, but it may be used for stock up to 3 inches in thickness. It is 28 inches high and weighs about 120 pounds. Special bands are furnished when it is desired to cut light metal or fiber.

EXPANDING PLUGS

With a view to lessening the tool-room costs of making jigs, punches, dies, master plates, and similar parts, the Expanding Gauge Co., 716 Reibold Bldg., Dayton, Ohio, is introducing to the trade a set of twenty-four expanding plugs which have a wide variety of applications. Each

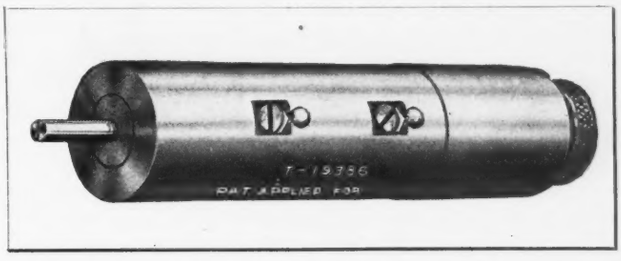


Fig. 1. One of a Set of Twenty-four Expanding Plugs made by the Expanding Gauge Co.

plug has six pins, which are placed radially in pairs of three, with their inner ends bearing on a taper shaft at the center of the plug. A screw is attached to one end of the taper shaft, and on this screw is mounted a nut. By means of the screw and nut the taper shaft may be adjusted longitudinally to cause the pins to expand or withdraw.

These plugs are especially valuable in accurately checking the center-to-center distance between two holes. A plug

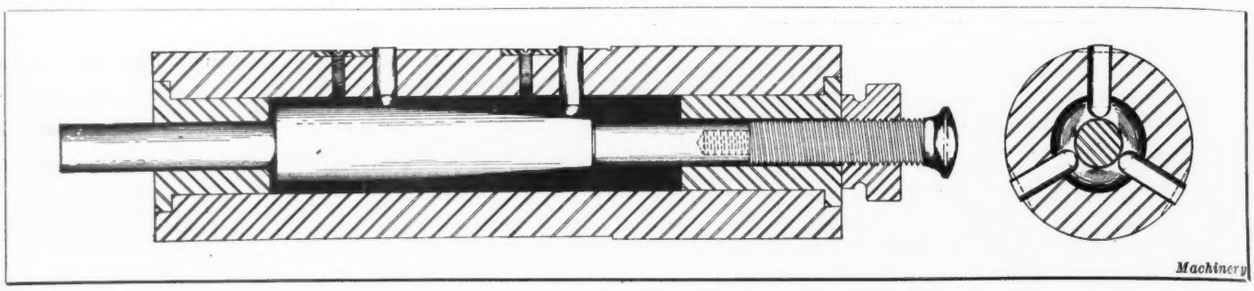
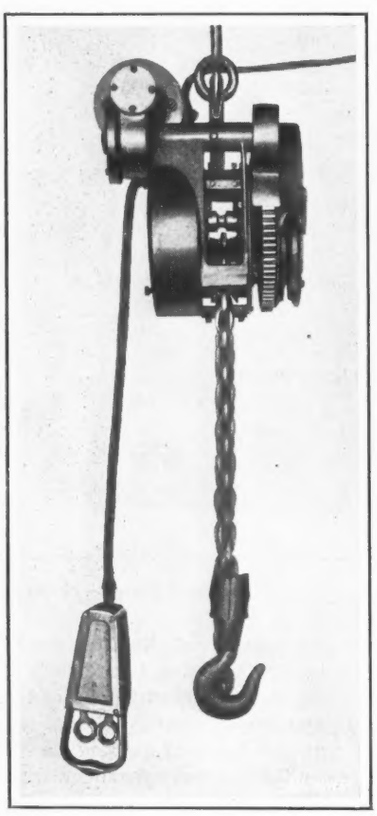


Fig. 2. Cross-sectional View, showing the Construction of the Expanding Plugs

is inserted in each hole, and the pins expanded until the plug fits the hole as desired, after which a vernier caliper or micrometer reading is taken over the two plugs. The diameter of a hole may also be determined by expanding the pins and measuring the expanded diameter after the plug has been removed from the hole. These plugs eliminate the necessity of making soft temporary plugs for determining the center distance between holes, and of making solid plug fits. The full set of twenty-four plugs provides for measuring and fitting 1248 holes, varying from 0.498 to 2.0005 inches in diameter. The 1-inch plug, for instance, will fit holes from 0.998 to 1.063 inches, varying by increments of 0.0001 inch. The total expansion on the smaller sized plugs is 0.0352 inch, and on the larger sizes 0.065 inch.

MOTORBLOC CHAIN HOIST

A chain hoist having a motor that drives through reduction gearing and a friction clutch is now being manufactured in various sizes with capacities of from ¼ to 10 tons, by the Motorbloc Corporation, Summerdale, Philadelphia, Pa. This equipment is intended for service intermediate between that of the overhead crane and the hand hoist. The motor and other driving members are attached to the hoist proper by a malleable iron bracket, and thus comprise a self-contained driving unit, which is started and stopped through a pendant controller. As only one hand is necessary to operate this controller, the other hand is always free to guide the work being lifted. Electric current may be supplied to the motor by plugging into the nearest circuit connection.



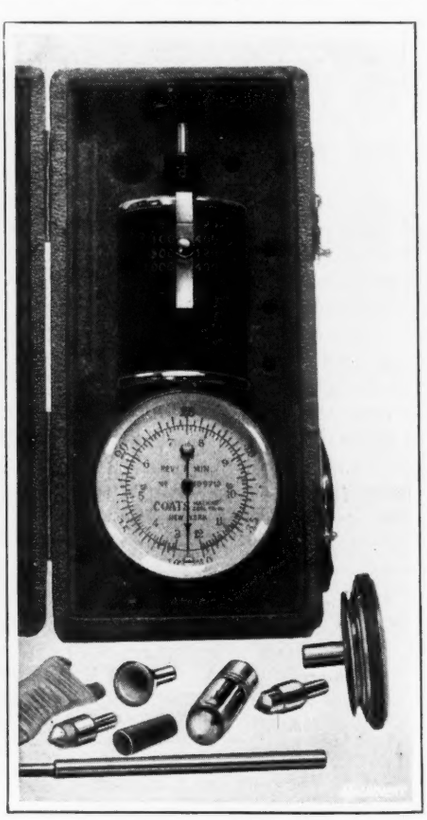
Motorbloc Chain Hoist

Care was taken in designing the hoist to make it compact and well balanced. It is said that by using high-grade materials strength has been obtained with lightness, the weight of the one-ton size being 148 pounds. The armature shaft and worm are carried in heavy-duty ball bearings, and supplied with automatic lubrication. The friction clutch is of the ring-oiled type; it prevents damage from over-running of the hoist, and also protects the motor from overload. It is claimed that by means of this hoist one man can handle parts that ordinarily require two or three men to lift and place. When electric current is not available, a hand chain can be quickly applied to operate the hoist as an ordinary block. Although regularly furnished with a complete hoist, the self-contained driving unit can also be readily applied to standard chain hoists.

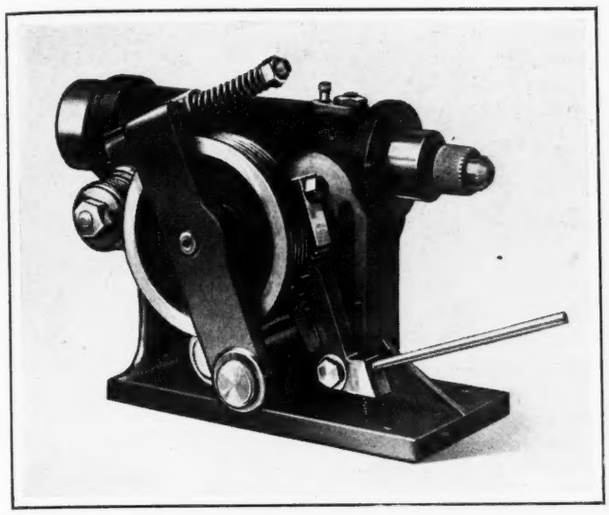
COATS HAND TACHOMETER

A hand tachometer designed on the pendulum or governor principle and having a mechanically operated level which indicates whether or not the instrument is being held in horizontal alignment with the shaft being tested, is being placed on the market by the Coats Machine Tool Co., Inc., 112 W. 40th St., New York City. The instrument is so balanced, however, that it may also be used when held vertically. The number of revolutions per minute of a member is read directly on the dial. A rubber-bound cutmeter wheel having a circumference of 6 inches is used in determining the surface speed of a member, in which case the dial reading is divided by 2 in order to find the speed in lineal feet per minute.

A damping mechanism eliminates vibration, and it is said that magnetic or electrical influences, or moisture and temperature changes do not affect the accuracy of the instrument. A steel coupling is used in determining speeds up to 200 revolutions per minute and a rubber coupling for greater speeds than this. An extension bar is provided for use in determining the speed of an internal surface or part. This tachometer is made in three- and four-speed types for determining speeds from 30 to 16,000 revolutions per minute. The instrument illustrated is of the four-speed type. Both types weigh about one pound and are small enough to fit the palm of the hand.



Coats Hand Tachometer



Kingsbury Ball-bearing Automatic Sensitive Drill Head, which may be used Singly or in Groups

KINGSBURY AUTOMATIC SENSITIVE DRILL HEAD

An automatic sensitive drill head which may be employed in connection with a work-holding fixture to obtain high production rates on small work has been brought out by the Kingsbury Mfg. Co., Keene, N. H. Several of these heads, one of which is here illustrated, may be mounted on a bench and tended by one operator when they are used for single-hole drilling. The operation of the head is simple; the attendant merely places the work in position, clamps it and then presses the trip-lever to release the spindle-feeding mechanism. On such a job as drilling six or eight oil-holes in a piston, the holes can be drilled simultaneously by spacing the drills properly about a circle and connecting a ¼-horsepower motor to each. The trip-levers in such an installation should be connected to one foot-treadle so that the spindle-feeding mechanism of all the heads will be released by one motion of the operator.

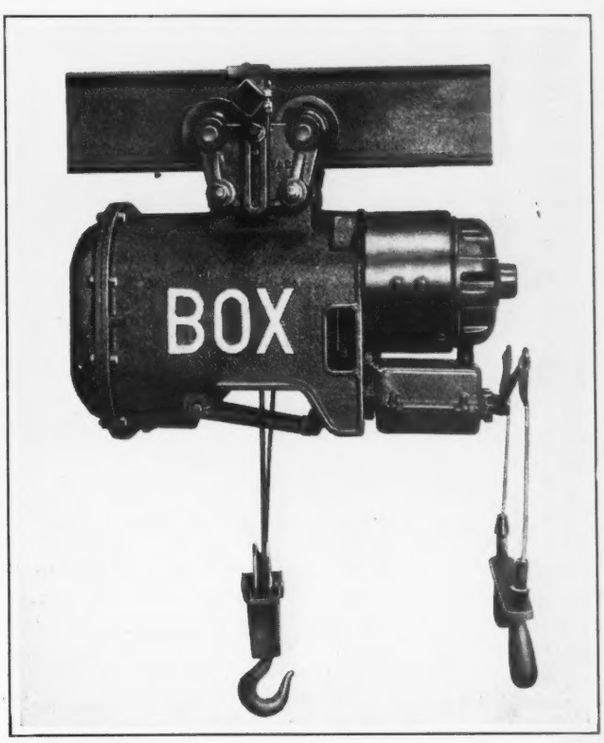
An automatic sensitive feed for the spindle is furnished by combining a cam with friction gears. The driven gear is mounted on a lever, and held in mesh with the friction driving roll or gear by an adjustable compression spring, the cam being cut on the inside of the driven gear. A follower roller is mounted on a gear segment, which meshes with a second segment clamped to the feed-shaft. The compression spring applies pressure to the drill spindle through the cam to the follower, and thence through the gear segments to the feed-shaft and quill. The cam is revolved by the friction gears and feeds the spindles forward under pressure. When this forward motion is resisted, as when the drill strikes the work, the follower roller is held momentarily and the rotation of the gears causes the cam to climb on the roller, thereby separating the friction gears and allowing them to slip.

As the drill penetrates the work under pressure, the follower gives way, bringing the friction gears into tight contact and causing the cam to revolve and again separate the friction gears when further resistance is met. However, this intermittent motion is not perceptible, the action being rapid and smooth. The standard cam gives a one-inch stroke to the spindle with a maximum feed of 0.011 inch per revolution, and there is a spindle adjustment of two inches. The drill is permitted to approach the work and break through at a comparatively rapid rate of feed, yet slowly enough to prevent injury to the drill. The actual drilling feed depends on the pressure adjustment, the hardness of the work, and the condition of the drill. Special cams with one or two reliefs may be used to permit the withdrawal of the drill during the operation so that chips can be removed. The cam may be cut on the outside of the friction gear for operating indexing and other automatic fixtures. This cam must be designed to function only during the idle or non-drilling time of the head; otherwise, the sensitiveness of the spindle feed would be impaired. This drill head is intended to receive drills from No. 60 to ¼ inch. It is regularly furnished with a No. 7 Jacobs chuck.

BOX "LOAD LIFTER" ELECTRIC HOIST

An electric hoist which is rated to lift a load of 1000 pounds on a two-part line at a speed of 20 feet per minute, or a load of 500 pounds on a single-part line at the rate of 40 feet per minute, is now being placed on the market by Alfred Box & Co., Inc., Philadelphia, Pa., under the trade name of "Load Lifter." A feature of this hoist is that the trolley, which runs on the lower flanges of an I-beam, may be attached to the hoist as shown in the illustration, to bring the hoist parallel with the I-beam, or it may be mounted to bring the hoist at right angles to the I-beam. The trolley may also be replaced by a hook suspension. All these changes are simply effected. The trolley is adjustable so that the hoist may be used on 5-, 6-, 7-, 8- or 9-inch standard I-beams.

Attention is called to the compactness of the design, the hoist being only 28 inches long by 11 inches wide. Another point of interest is that the hoist is automatically lubricated from one point by a combination of the splash and forced-feed systems. It is only necessary to pour oil into the hoist about once every six months. The equipment is fully enclosed, all parts operating in oil-tight dust-proof cases. Because the motor and controller are totally enclosed, the hoist may be installed anywhere. Hyatt flexible roller bearings are supplied everywhere except for the motor bearing where the S K F self-aligning ball bearing is used. All gears have stub teeth, are made of forged steel, and are heat-treated, and all shafts are made of manganese steel. The controller is built especially for the hoist and is basically of the drum type. It has non-arcing fingers, and is insulated with bakelite. The controller cover is hinged to facilitate inspection, and a terminal block is built in the controller to make wiring easy. The hoist has a drum that accommodates about eighty feet of rope.

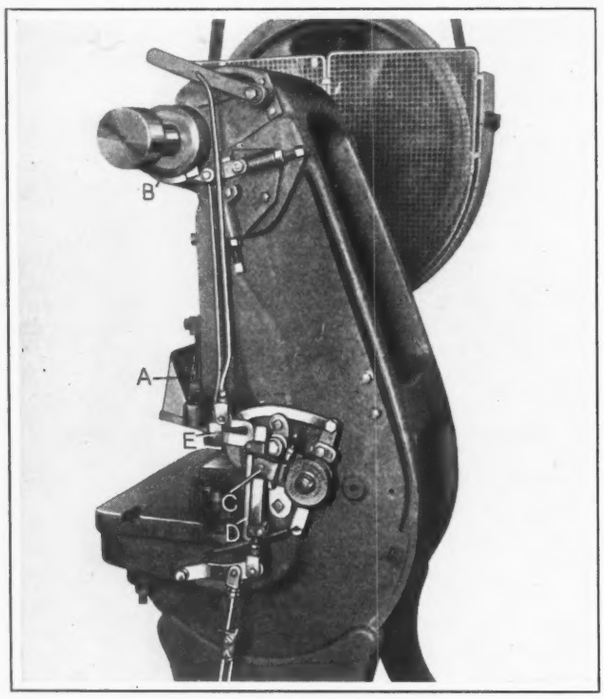


Box "Load Lifter" Electric Hoist, which will lift 1000 Pounds at the Rate of 20 Feet per Minute

KARTZMARK POWER PRESS GUARD

One of the exhibits that attracted considerable attention at the machine tool exhibition held recently at Yale University was a power press operated by a blind man. The safety of the operator was ingured by having the press equipped with a Kartzmark safety guard, which is manufactured by the Standard Safety Mfg. Co., 263-265 Park St., New Haven, Conn. The accompanying illustration shows this guard installed on a machine which has the flywheel temporarily removed to give a complete view of the guard mechanism. When the operator depresses the machine treadle to actuate the ram, the fender or housing *A* is lowered around the die-block, and this housing must be permitted to go all the way down before the press can function.

When the housing is completely lowered, latch *B* is operated through mechanism *C* and permits the ram to make a stroke. However, should the hand of the operator be on the die, it would interfere with the lowering of housing *A*, and as latch *B* then would not be released, the ram could not go down, and thus the operator would not be injured. After latch *B* has been pulled, a cam on the flywheel shaft

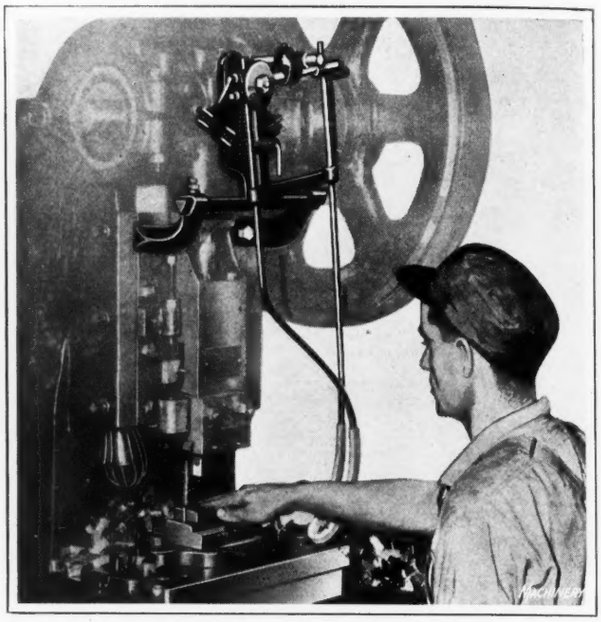


Power Press equipped with Kartzmark Safety Guard

holds the latch down until the ram has completed its stroke. Then a second cam on the flywheel shaft disconnects the treadle through latch *D* and draws member *E* back into position to relock the press. As the entire mechanism is operated automatically by cams, the operator has both hands free to insert and remove the work. An adjustment provides for limiting the upward movement of housing *A*, and there is another adjustment to suit dies of different heights. This guard mechanism does not interfere with tilting of the press.

WIESMAN POWER PRESS GUARD

Several improvements have recently been made to the power press guard manufactured by the Wiesman Mfg. Co., 14 N. Canal St., Dayton, Ohio, of which a complete description was published in May, 1920, MACHINERY. On a power press equipped with this guard the eccentric movement of a pin attached to the crankshaft bearing cap causes a swinging arm to sweep directly past the die, and pushes away the operator's hand, should he neglect to remove it from the die-block. The most important of the improvements is the

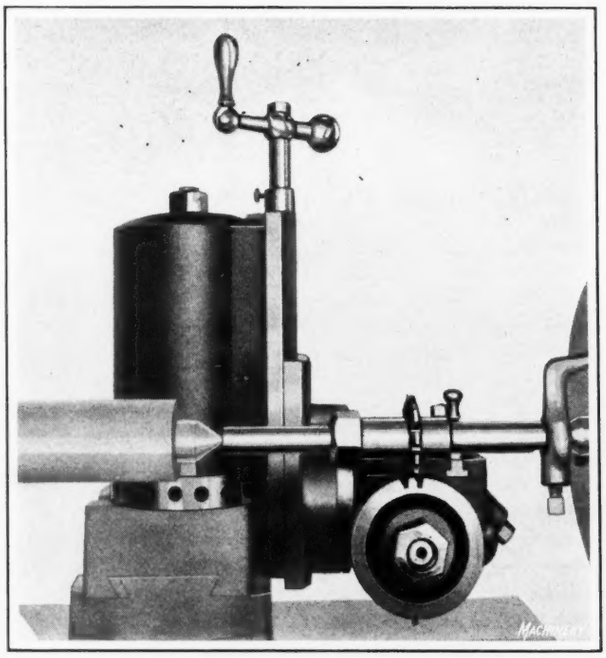


Wiesman Power Press Guard to which Several Improvements have been made

addition of two shock absorbers, which eliminate any vibration that might otherwise result as the swinging guard reaches the ends of its arc. An extra brace has been provided for the guard arm so that it is now supported at four points. The main bearing of the guard has also been enlarged, and the end of the swinging member, which contacts with the arm of the operator, is now provided with a molded piece of rubber, instead of the ordinary rubber tubing formerly supplied.

GARRETT LATHE MILLING ATTACHMENT

A patented attachment known as the "millerette converter," which has been developed for application on lathes to enable milling operations to be performed, but which may also be mounted on planers, shapers, and drilling machines, is now being placed on the market by the Production Machine Tool Co., 629 E. Pearl St., Cincinnati, Ohio. The device is built in three sizes for lathes from 12 to 24



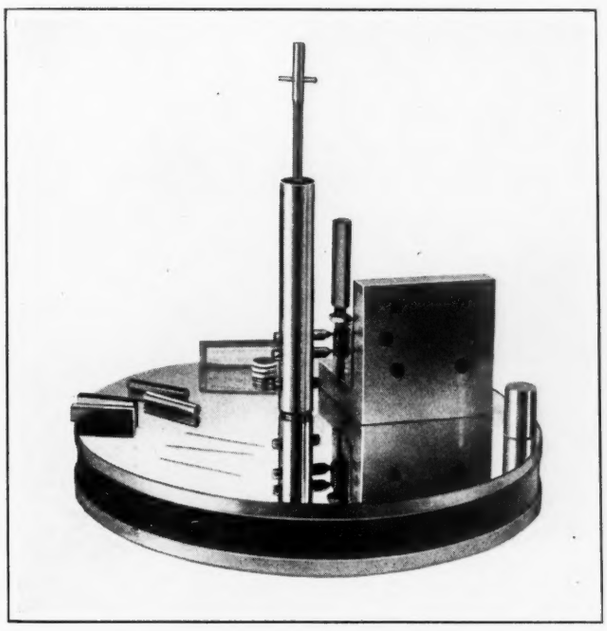
Garrett "Millerette Converter" which may be applied to Various Machine Tools

inches swing. The work is mounted on the spindle of the device, and the cutter is carried on an arbor held between the headstock and tailstock centers of the lathe. Thus the lathe provides longitudinal and cross feeds for the cutter, while the work may be fed vertically by operating the slide of the attachment by means of a handle at the top.

The attachment has a dividing head, which permits such operations to be performed as the cutting of spur and bevel gears, surface milling, angle-cutting, splining, and keyways-ing. The dividing head is operated through change-gears which may be quickly set up, only two gears being used at one time. An index-plate shows what gears should be used, and gives the required number of turns of the index-handle to obtain any division from 2 to 360. The attachment fits the toolpost slot in the top slide of the compound rest of the lathe, and is quickly clamped in position. When attached to a drilling machine, the attachment enables the accurate drilling of holes and when used on a planer or shaper, it serves the same purpose as a dividing head.

VAN KEUREN STEEL SURFACE PLATES

The high degree of polish on the lapped surface of a new line of hardened steel surface plates being introduced to the trade by the Van Keuren Co., 361 Cambridge St., Allston, Boston, Mass.. will be evident from the accompanying illustration, in which the reflections of parts lying on the lapped surface are as distinct as the parts themselves. At first glance it would seem as if in each case two identical parts were resting on each other. These surface plates are inspected during their manufacture by means of light waves. Gage-blocks may be wrung directly on the lapped surface. The plates are made in three sizes—5, 8, and 10 inches in diameter, respectively. They may be furnished with two handles, which are screwed into the edge of the plates, and also with a wooden box to protect the precision surface.



Van Keuren Steel Surface Plate

NEW MACHINERY AND TOOLS NOTES

Motor-driven Tool Grinder: Forbes & Myers, 178 Union St., Worcester, Mass. A Model 75 tool grinder of the same design as the Model 76 described in July MACHINERY. The new model, however, is arranged for single-phase current, whereas the former model is intended for two- or three-phase current. The grinding wheels are so mounted that they may be worn three-quarters away before the periphery comes into line with the front of the motor. The wheels are 6 inches in diameter, and ¾ inch thick.

Roller Bearing: Whitney Bearing Corporation, 467 E. Ontario St., Chicago, Ill. A roller bearing in which the rolling action is obtained by means of disks. The rollers operate between parallel taper surfaces, the construction being such as to eliminate end thrust and the accompanying friction, which occur when taper rollers are used. The load is transmitted to the face of the roller only in a direction perpendicular to the axis of the roller. The series of rollers are carried in separate ring cages, as the rollers near the apex of the cone travel faster than those near the base. An adjustable spring permits just the right pressure to be exerted to keep the bearings in complete contact.

Portable Electric Grinding Machines: Saphil Electric Tool Co., Galesburg, Ill. A portable electric internal and external grinder, designed for attachment to various types of machine tools, including the lathe. This company has also brought out a portable electric valve grinder, in which the motor is held above the spindle on two supports, and drives the spindle through a belt. The motor can be raised or lowered on its supports. The wheel-slide base can be accurately adjusted by a micrometer screw having a dial graduated in thousandths of an inch. Both grinders are supplied with an extension for internal operations. The sales agent is the General Tool & Equipment Co., Chicago.

Inclinometer: Stevens-Prentice Mfg. Co., 377 National Ave., Milwaukee, Wis. A device intended for use in reading and checking bevels, angles, and levels. This instrument obviates mathematical calculations in determining or laying out angles. It has an aluminum housing which is mounted on a semi-steel base and carries a graduated dial. A vernier pendulum is pivoted at the center of the dial. The vernier is read in the same manner as the ordinary vernier caliper. A small brake can be employed to stop the oscillation of the pendulum and hold it stationary while taking a reading. The instrument may be held in any position for taking a reading, because the dial is graduated throughout its full circumference.

Power-feed Hollow-chisel Mortiser: Oliver Machinery Co., Grand Rapids, Mich. A hollow-chisel mortiser, somewhat larger than a machine of the same type described in October, 1921, MACHINERY, which is equipped with a power feed combined with a motor in the head. The power feed is controlled by a foot-lever, being brought into action by a belt tightener which, when released, brings a brake into action on the rim of the driving pulley. A ratchet holds the lever down for continuous operation. The power feed furnishes three stroke speeds of 18, 26, and 36 per minute through cone pulleys and a feed-belt shifter. By throwing out the ratchet, the continuous feed mechanism can be stopped instantly, and the machine operated by single strokes. Another feature is a rotary fan or blower direct-connected to the motor and placed directly above it. This motor is mounted on a shaft of the machine and furnishes a constant air blast for cooling the tools and keeping the work free from chips.

* * *

EIGHTIETH ANNIVERSARY OF RYERSON & SON

The firm of Joseph T. Ryerson & Son, of Chicago, Ill., celebrates this month its eightieth anniversary. Joseph T. Ryerson arrived in Chicago in 1842 as the accredited agent of Wood, Edwards & McKnight, Pittsburg iron masters. He rented a small two-story brick building at the corner of Clark and Water Sts. for $200 a year. The next year Mr. Ryerson moved his store to 90 Lake St., and a little later established a branch store at Urbana, Ill. In 1844 he secured land at 74 Lake St. and erected a two-story building, stocking it with heavy and light hardware, in addition to the heavy iron and steel products from Pittsburg.

In 1852 he purchased a dock lot, with an 80-foot front on the river at 218-224 S. Water St. In this location the business grew until October 9, 1871, when the great Chicago fire reduced the building to ashes. The burned store was rebuilt March 15, 1872. About ten years later property was purchased at 18-22 Milwaukee Ave., and a three-story office and warehouse building was erected. This building was soon enlarged, and in 1908, still larger quarters being necessary, the first buildings of the present plant were erected.

Today the Chicago plant occupies a ground area of over nineteen acres, with nearly a million square feet of floor space. In 1914 the company purchased the W. G. Hagar Iron Co., in order to serve the southwest territory direct from St. Louis. In 1915 the New York plant was built, and in 1917 the Detroit plant. The warehouse division of the Ferguson Steel & Iron Co. at Buffalo was purchased in 1919. The firm of Joseph T. Ryerson & Son now serves the entire country from five large steel-service plants, and there are offices in the principal cities to complete the organization.

STRENGTH
for firm support—
ACCURACY
for uniform production

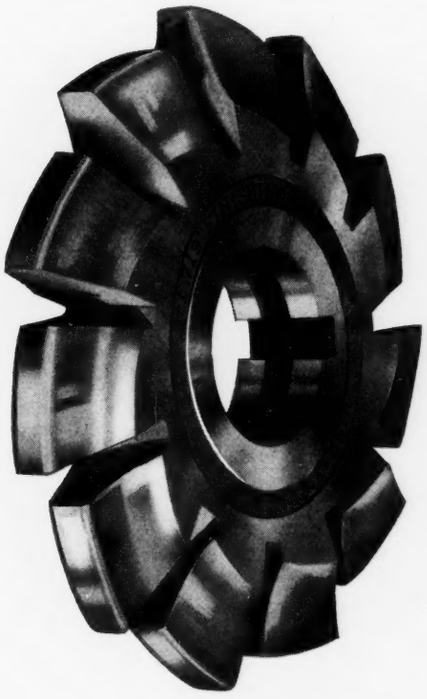
BROWN & SHARPE
Automatic Gear Cutting Machines

STRENGTH—to hold these big 3-ft. drums true during cutting. Note the long bearing for the work arbor, and the rugged column and work support.

ACCURACY—to insure uniformity in the finished drums. Accurate spacing of the teeth is insured by the extreme accuracy of the index wheel of large diameter in proportion to the diameter of the work. The indexing mechanism operates without shock—an added insurance of accuracy. Absence of shock is important with work of large size which quickly shows the effect of any sudden jar.

Consider these features in connection with your own gear cutting problems.

Write for Catalog No. 137 describing our Gear Cutting Machines.



Unlimited Duplication of High-quality Gears

The ability to duplicate high-grade gears is the ambition of every maker of gears in quantity. For this exacting work he installs the best machinery and hires the most competent mechanics. He should also secure the most accurate cutters available—Ground-Form Gear Cutters—cutters of unvarying, uniform accuracy with which accurate gears can be duplicated again and again.

BROWN & SHARPE GROUND-FORM GEAR CUTTERS

are ground on the form, correcting all hardening distortions. This method of controlling the tooth form means that duplicates of any Ground-Form Cutter are always available. The ability to secure duplicates of these accurate cutters makes it possible for gear makers to produce unlimited quantities of the uniformly accurate gears demanded by modern requirements.

In addition to their higher accuracy, Ground-Form Gear Cutters have a freer cutting action which greatly increases production. Grinding the teeth on their forms eliminates all hardening distortions and prevents any tooth or group of teeth from doing the major part of the work. Every tooth must do its share. The increased production which results from this freer cutting action has been shown by actual test to be surprisingly great.

Secure the combined benefits of higher accuracy and increased production—use Ground-Form Gear Cutters on your most exacting work.

Brown & Sharpe Ground-Form Gear Cutters are available in sizes from 1¾ to 12 pitch inclusive.

Write for further information.

BROWN & SHARPE MFG. CO.

Providence, R.I., U.S.A.

Apprenticeships*

By P. C. MOLTER, Superintendent of the Department of Industrial Education, National Metal Trades Association

THE National Metal Trades Association has taken active steps to revive the practice of apprentice training in the metal trades industries; an explanation of the causes for this action may be in order at this time. The metal trades industries as a whole have adopted the economic principles of the division of functions, the simplification of processes, and the specialization of operations until there is little resemblance between the production methods of today and those of earlier times. This is especially true in the manufacturing industries where mass production is the order of the day.

One direct result of this change in method is the fact that unskilled or semi-skilled workmen can be readily taught to perform the comparatively simple special operations in very short periods of time, when instruction is systematically given; and ability to earn comparatively large wages follows this acquirement of productive capacity. It naturally follows that a great many workmen are satisfied to remain in the industry as specialists, rather than serve the comparatively long period necessary to complete an apprenticeship, especially when they see that the actual money earnings of the highly skilled man are but slightly greater than their own. Also a great many bright young men have reasoned that they could earn the pay given to specialists, keep their eyes open, and thus learn the trade. This has continued until today it is practically impossible to find enough men to fill the positions in industry which are best filled by those who have a broad practical experience and all-around training and skill.

Need for Apprenticeships

Investigation in the metal trades industry has shown that most employers are painfully aware of the shortage of this class of help, but that comparatively few are providing the means whereby the necessary training can be given. Their reasons range from their inability to provide a complete and varied line of experience, to the frank statement that they are tired of spending time, effort, and money to bring boys along until they become useful and then have them leave for some other shop.

The Committee on Industrial Education of the National Metal Trades Association realizes the consequences that must inevitably follow continued indifference to the maintenance of an adequate supply of skilled workmen, and in an effort to arouse industry to action, has prepared a manual on apprenticeship which contains the fundamentals for apprentice training in any machine shop, regardless of its size, the training method employed, or the type of the product.

Apprenticeships in Gear Shops

In a highly specialized industry like the gear-cutting industry, it would be unreasonable to expect or require that a large proportion of the operative force should be apprentice-trained. However, such shops have the same equipment that is found in most machine shops, as well as the special machinery peculiar to the gear business. Aside from the specialists who operate the machinery for producing gear teeth, this industry needs men who can operate the standard machine tools, and also maintenance, repair, and experimental men, tool, jig, and fixture makers, jobsetters, and men who can be assigned to any of the production machines when a workman is absent for any reason; it also needs a few who are prepared to become foremen and leaders. This is the group of workmen who need the broad general training best given through a carefully planned apprenticeship. A modified apprenticeship could be devised for the operators of the gear-cutting machines. One plan would be to divide these men into three groups—those who operate machines depending on formed cutters, those who operate generating machines, and those who operate the machines using the templet process. They can be taught their specialty in a much shorter time than is served by the ones who plan to become all-around skilled mechanics.

Methods of Training Apprentices

Granting that apprenticeship training is desirable and necessary, how can it be accomplished? First, there is the group of employers who feel that they should assume complete supervision of the training given to their employes. They will set up some method whereby their apprentices shall receive all their training within the plant of the employer, without any assistance from outside agencies. Should several of these employers be neighbors, they may pool their training and share the expense of supervision and instruction.

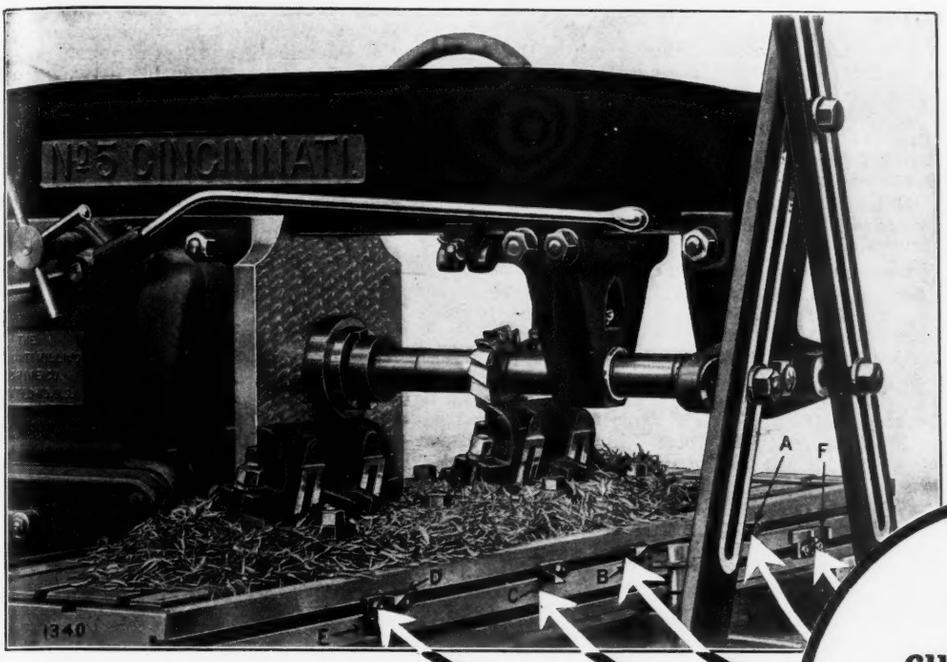
Second, there is the group that will take advantage of the facilities provided under the terms of the Smith-Hughes Law which provides federal assistance for vocational instruction. Practically all cities now have trade preparatory, trade continuation, and trade extension schools, which are supported by federal, state, and local funds. Many of these schools are doing excellent work and should be considered when plans for training are being made. Another form of the Smith-Hughes Law instruction is that given by itinerant instructors who travel from shop to shop on a regular schedule and do their teaching within the plants of the employers. All of this Smith-Hughes instruction is without expense to either employer or employe; my observation shows that the subject matter taught by the itinerant instructor is somewhat more closely related with the work of the individual plants than is usual in the other forms of federal and state aided instruction.

Third, there is the group that is willing to cooperate with the public schools, but that is unwilling to have machinery standing idle while the apprentices are attending classes. The cooperative school appeals to this body. Under this plan, the apprentices are paired, one being in school while the other is at work. The week-about and the two-weeks-about schedules seem to give more satisfactory results than either longer or shorter periods of rotation.

Fourth, there is the group that prefers to cooperate with private or semi-private trade schools in which the teaching methods are similar to those already outlined, the main differences being that tuition fees are required and that instruction can be arranged to meet the individual needs of the employer and apprentice more closely than is possible in most public schools.

These methods are being followed by employers who are trying to do their share in keeping up the supply of skilled workers. Each of these plans is susceptible of many variations. The only generalities that hold good in every case are that a definite plan must be followed, and someone must be directly responsible to the management for the success of any training method in operation for the education of apprentices.

*Paper read before the American Gear Manufacturers' Association's convention in Chicago, October 9, 1922.



They cut down the non-productive minutes — *automatically*

The Intermittent Feed on the Cincinnati Millers Nos. 4 and 5—

—is one of the time-saving features that has made our Automatics so successful. It works on the Nos. 4 and 5 Cincinnatis just as well.

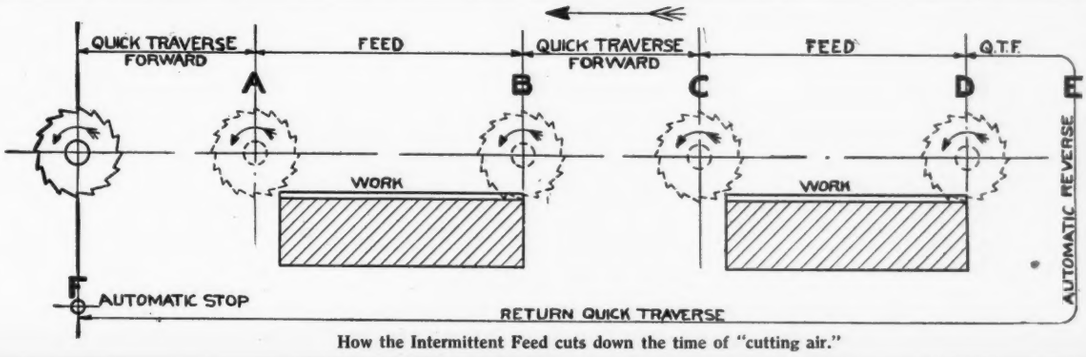
There is nothing complicated about it. All millers have dogs for limiting table travel. This feature is simply a step beyond.

The diagram below shows the cycle of operation in the photograph. Assume the machine ready to start. The operator engages the feed. The table advances at 100 in. per minute to the work; dog "A" trips to the feed rate; dog "B" engages the forward quick traverse between the pieces; dog "C" again trips to the feed rate and dog "D" engages the forward quick traverse, while immediately behind it dog "E" automatically reverses the quick traverse movement, which brings the table back to the starting point and it is stopped by dog "F."

Can the intermittent feed be arranged to expedite your production? Ask our Service Department.

The Cincinnati Milling Machine Co.

Cincinnati, Ohio



How the Intermittent Feed cuts down the time of "cutting air."

OBITUARIES

HERBERT C. FOLLINGER, manager of the Chicago office of the Chain Belt Co., Milwaukee, Wis., died of pneumonia at his home in Chicago, September 27, after a few days illness. Mr. Follinger was thirty-eight years of age at the time of his death. He was born in Fort Wayne, Ind.; in 1902 he graduated from the Chicago Manual Training School, now part of the University of Chicago, and subsequently entered the employ of the Otis Elevator Co. He became connected with the Chain Belt Co. in 1914, and in 1916 was appointed district manager for the Chicago territory.

FREDERICK E. ANTHONY, who for many years was in charge of the automatic screw machine tool designing at the plant of the Brown & Sharpe Mfg. Co., Providence, R. I., died October 8 on his fifty-eighth birthday. Mr. Anthony was born in East Providence, and at the age of seventeen entered the employ of the Brown & Sharpe Mfg. Co. as an apprentice. He remained with the company until January, 1890, after which he worked with the Eastman Kodak Co. and with Bugbee & Niles of North Attleboro. In October 1898, he again returned to the employ of the company, where he remained up to the time of his death.

Mr. Anthony represented the type of a trained mechanic who has made so much for the progress of mechanical lines in this country. He was fertile in devising ways and means of doing work, and his sound mechanical judgment and training kept him from various pitfalls that are so likely to embarrass a mechanical genius. Through his advice and experience, many of the details of the automatic screw machines were brought out, and there is hardly a large manufacturing plant in the country making use of this type of machine that is not using some of the plans that Mr. Anthony worked out. His loyalty to the company was such as showed itself in continually seeking to advance the solution of problems of customers with whom he came in contact. As a companion and shopmate, his untiring courtesy and cheerfulness made him a man who was able to impress himself upon all who came in contact with him as a companion to be cultivated from a sense of pure friendship.

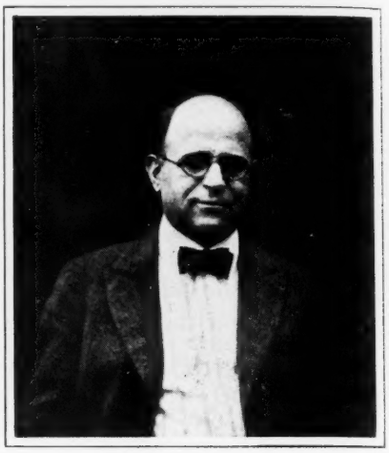
M. L. BAILEY

M. L. Bailey, treasurer of the Union Mfg. Co. of New Britain, Conn., died in that city on September 26. Mr. Bailey was in his sixty-sixth year at the time of his death and had been connected with the Union Mfg. Co. for more than forty-five years. He was elected secretary in 1884, a director in 1887, and treasurer in 1888. The latter two offices, director and treasurer, he had held continuously since his election. Mr. Bailey was married in 1881 to Miss Georgiana C. Prickett, of Hazardville, Conn., who survives him. There are no surviving children. He was a member of the Official Board of the Trinity Methodist Episcopal Church, which position he held for a number of years, having given considerable of his time to the work of that church. Mr. Bailey was widely known all over the country in the hardware and machinery trades and had made many warm friends who will deeply regret his loss.

CHARLES S. GINGRICH

Charles S. Gingrich, for twenty-two years with the Cincinnati Milling Machine Co., Cincinnati, Ohio, and for many years in charge of the company's sales engineering department, died in Cincinnati, October 10, at the age of forty-eight years. Mr. Gingrich was widely known in machine tool circles throughout the country as one of the most active men in the business and as an acknowledged expert in his particular field. He was one of the group of able men who, during the last twenty years, have brought the Cincinnati Milling Machine Co. to its present position in the machine tool field.

Mr. Gingrich had many broad interests aside from his regular work. He took a deep interest in the engineering work of the University of Cincinnati, and in the young men in that institution. The very human side of his personality showed itself at its best in his contact with the young students, particularly those in need of advice and council.



He had also a great interest in scientific subjects of a most diversified character — physics, astronomy, botany, and chemistry. These subjects occupied much of the time he could spare from his business career. Naturally, his mind turned frequently from the abstract scientific principles to their practical application, and his ideas as to the relation of science to business stimulated his unusual interest in engineering education.

JOHN B. FOOTE

John B. Foote president and treasurer of Foote Bros. Gear & Machine Co., Chicago, Ill., died suddenly on October 12 from an acute attack of gastritis, aged fifty-seven. Mr. Foote was a pioneer in making cut steel, casehardened gears for heavy-duty work, especially for use in farm tractors, and was known throughout the country for his skill as a gear-maker.

Mr. Foote was born April 6, 1865 and at the age of fourteen became a die-setter for the Chicago Stamping Co. When he was seventeen he was made foreman of the press and stamping room of the Cragin Mfg. Co. He became successively diemaker and toolmaker for Norton Bros. (now the American Can Co.), superintendent of machinery for the Cragin Mfg. Co., in charge of the machine shop of the American Can Co., and designer and builder of special machinery for the Fisher Mfg. Co. From 1893 to 1904 he was a partner with D. O. James in the firm of James & Foote, manufacturers of cut gears. When the business was wiped out by a disastrous fire in 1904, he organized the Foote Bros. Gear & Machine Co., which soon became one of the largest and best-known gear concerns in the country.

Mr. Foote shared with Henry Ford and Thomas L. Fawick the honors of pioneering the present light-weight type of farm tractor, with its live axle drive and all-enclosed transmission and with the engine, gear, and axle housings bolted rigidly together so as to render unnecessary the use of a frame. He was also the inventor of numerous automatic machines for making cans, and was regarded as an authority on machinery of many special types in which gears and cams are used. He was president and director of the Illinois Tractor Co., treasurer of the American Tractor Association, a director of the American Gear Manufacturers' Association, and a member of the Society of Automotive Engineers. He is survived by his widow and a brother, Bradford Foote who will continue the business of Foote Bros. Gear & Machine Co.

* * *

CATALOGUES REQUESTED FOR CHILE

Commercial attaché C. A. McQueen, Casila 27-D, Santiago, Chile requests American firms engaged in machine building, who are interested in export trade, to send catalogues for the files of his office; in case the manufacturer has an agent or representative in Chile, the name and address of the representative should also be furnished. It is suggested that catalogues should be forwarded by registered mail, because parcels-post packages are subjected to a delivery charge in Chile, an expense which naturally the American manufacturer would not expect either the commercial attaché or his prospective customers in Chile to carry.

It is stated that at present there is particular interest in woodworking machinery, especially of the motor-driven type, as there is a constant trend toward the use of electricity for power purposes. Large hydro-electric developments are under way near Santiago, and it is expected that the rates made for electricity for industrial uses will be low enough to easily compete with the cost of steam power.

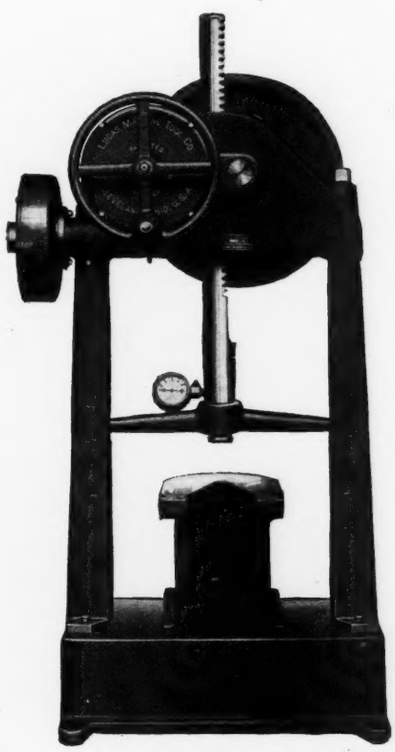
Take Us Into Your Confidence!

We frequently run across some peculiar job that can be done on the

LUCAS
Power Forcing Press

better than on any other machine.

If you have any jobs requiring pressure let us look them over, maybe we can help.



Illustrated Circular
Tells the Whole Story

WE ALSO MAKE THE
"PRECISION"

BORING, DRILLING AND MILLING MACHINE

LUCAS MACHINE TOOL CO., NOW AND ALWAYS OF **CLEVELAND, OHIO, U.S.A.**

FOREIGN AGENTS: Alfred Herbert, Ltd., Coventry. Societe Anonyme Belge, Alfred Herbert, Brussels. Aux Forges de Vulcain, Paris. Allied Machinery Co., Turin, Barcelona, Zurich. Benson Bros., Sydney, Melbourne. V. Lowener, Copenhagen, Christiania, Stockholm. R. S. Stokvis & Zonen, Rotterdam. Andrews & George Co., Tokyo.

TRADE NOTES

CINCINNATI PLANER CO., Cincinnati, Ohio, announces an advance of 10 per cent in the prices on vertical boring and turning mills.

BRIDGEPORT BRASS CO., Bridgeport, Conn., has opened a Detroit office in the General Motors Building, Detroit, with Frank H. Longyear as district manager.

DOWN TOOL WORKS, INC., Fleetwood, Pa., announces that H. H. Colbus will represent the company in the Philadelphia territory in the sale of high-speed drills and tools. Mr. Colbus was formerly sales representative in the Philadelphia territory for the Halcomb Steel Co.

ALFRED BOX & CO., Ontario St. and Trenton Ave., Philadelphia, Pa., manufacturers of electric cranes and hoists, have opened a New York office in charge of N. C. Failor. This office will handle the sales for Connecticut, Greater New York, and northern New Jersey.

FROSTHOLM BROS., Syracuse, N. Y., tool manufacturers and cylinder grinders, have purchased a new factory at 1009 S. Clinton St., Syracuse. The new location is central, and the company is installing new equipment which will enable an increasing volume of business to be handled.

ALVORD REAMER & TOOL CO., Millersburg, Pa., announces the appointment of C. C. Strout in the capacity of vice-president in charge of sales. Mr. Strout was formerly connected with the Victor Saw Works, as western sales manager, and with the Safety Wrench & Appliance Co., as general sales manager.

HARTFORD TAP & GAUGE CO., Hartford, Conn., has changed its name to the HANSON TAP & GAUGE CO. This change was made in order to connect the products of the company with the inventor and originator of its processes and equipment. No change has been made in the conduct of the business.

MURCHEY MACHINE & TOOL CO., 34 Porter St., Detroit, Mich., has decided to discontinue its New York office. The company's California agency was formerly handled by Harron, Rickard & McCone. This agency is now in the hands of the Smith-Booth-Usher Co., 50-60 Fremont St., San Francisco, and 228 Central Ave., Los Angeles, Cal.

WALTER S. RYAN CO. has recently been organized in Detroit, Mich., to deal in new and used machinery. A store has been opened at 130 E. Larned St. Mr. Ryan worked for the Potter & Johnston Machine Co. for four years in Michigan, Ohio, and western Pennsylvania. Previous to that he was connected for three years with Charles A. Strelinger & Co., of Detroit.

BROWN INSTRUMENT CO., Wayne Junction, Philadelphia Pa., has opened a New England branch at 185 Devonshire St., Boston, Mass., with George Goodman in charge. The company has also opened a southern branch at 619 Brown-Marx Bldg., Birmingham, Ala., with Charles L. Saunders in charge. These local offices will be completely equipped for sales and service.

F. S. PEARSON ENGINEERING CORPORATION, Fisk Bldg., 57th St. and Broadway, New York City, has re-established its department for industrial management and technical auditing of industries and public utilities. This department will be carried on together with the company's usual work of financing, developing, designing and constructing engineering projects and industrial plants.

R. G. HASKINS CO., manufacturer of flexible shaft equipments and portable tools, moved to larger quarters on November 1 at 516 W. Monroe St., Chicago, Ill., which affords large store space for the display and demonstration of machines, as well as larger facilities for handling the routine of the business. A display room will be maintained where machines can be tested out on a great variety of actual operations.

MELDRUM-GABRIELSON CORPORATION, Syracuse, N. Y., manufacturer of Gabrielson milling machines, Syracuse adjustable-limit snap gages, and special machinery and tools, has purchased and removed to its new plant at 601-607 W. Fayette St., the entire equipment and business of the KILLINGTON MACHINE CO., and is now prepared to undertake contracts for screw machine work, gear-cutting, and production grinding.

METALLO GASKET CO., New Brunswick, N. J., announces that its business has grown to such proportions that it has become necessary to establish a general sales office at 242 Lafayette St., New York City. A complete stock of the company's products will be carried in the New York office, and a staff of experts including P. L. Rhodes, William A. Gormley, L. A. Ward, and W. B. Goering, will be available on short notice for consultation.

PORTER-CABLE MACHINE CO., Syracuse, N. Y., manufacturer of lathes and vertical milling attachments, has purchased the SYRACUSE SANDER MFG. CO., and expects to move the business into its own plant, and sell the building and machinery of that company. The Syracuse Sander Mfg. Co. has been manufacturing disk sanders, oscillating-spindle sanders, belt sanders, band saws and wood lathes, all of which were motor-driven and designed especially for pattern shops.

NATIONAL TOOL CO., Cleveland, Ohio, has taken over the SIMMONS METHOD-HOB CO., of Philadelphia, Pa., including all the equipment, machinery and tools, patents, trademarks, and copyrights. The National Tool Co. proposes to manufacture immediately, under the Simmons Method patents, hobs with generated teeth for cutting gears, spline shafts, threads, hacksaw blades, machinists' files, pipe, taps, chasers, and sprockets for silent chains and roller chains, as well as hobs for special purposes.

INDUSTRIAL TOOL CO., 5518 Euclid Ave., Cleveland, Ohio, has just been organized. The principal line of the company will be machine tools, dies, and special machinery, and contract work will also be undertaken. The officers are as follows: President and general manager, G. H. Sommerfield; vice-president, C. M. Lee; and secretary-treasurer, Charles D. Gerland. Mr. Sommerfield has had many years experience in the mechanical field, and was connected with the J. C. Ulmer Co. of Cleveland, Ohio, for over eight years.

NORMA CO. OF AMERICA, Anable Ave., Long Island City, N. Y., has acquired the American patents and business of the Hoffmann Mfg. Co., of Chelmsford, Essex England, maker of Hoffmann roller, ball, and thrust bearings; and the line of Norma precision ball bearings will now be supplemented by Hoffmann precision roller bearings and other bearing products in the Hoffmann line. The Norma Co. will erect a new plant for the manufacture of Hoffmann products in America. In the meantime, they are being imported and sold under the regular Norma engineering service.

RIVETT LATHE & GRINDER CO., Brighton District of Boston, Mass., manufacturer of precision bench lathes, internal grinding machines and radial grinding machines, announces a change of address of its Detroit sales office, which is operated in conjunction with that of the Reed-Prentice Co., Becker Milling Machine Co., and Whitcomb Blaisdell Machine Tool Co., under the management of T. C. McDonald. The new quarters, which provide ample space for the exhibition of sample machines, are located at 6526 Cass Ave., opposite the General Motors Building. The sales force has been augmented by the addition of E. B. Barber, formerly superintendent of the factories of the Lafayette Motor Co.

PAWLING & HARNISCHFEGER CO., 3826 National Ave., Milwaukee, Wis., announces the appointment of the following agents for its machine tool line: Cadillac Machinery Co., Detroit, Mich., of which G. L. Campbell is president, will have the territory including the state of Michigan with the exception of the counties bordering on Lake Michigan and the extreme northern section of the state; the Cleveland Duplex Machinery Co., Cleveland, Ohio, of which G. J. Hawkey is president, will have the northern section of Ohio; and the Seifreat-Woodruff Co., with offices at Dayton and Cincinnati, will have the lower section of Ohio with the counties bordering on the Ohio River in the state of Kentucky.

PRECISION & THREAD GRINDER MFG. CO., 1 S. 21st St., Philadelphia, Pa., manufacturer of the multi-graduated precision grinder, thread lead variators, and permanent-alignment wheel-truing heads, which was recently acquired by A. T. Doud, president of the company, has appointed William H. Frick chief engineer in charge of the engineering, development, and service departments. Mr. Frick is a grinder expert, and is well known in the machine tool industry. Before joining this company he was equipment engineer for the Budd Wheel Corporation. He has been master mechanic at the Landis Tool Co., efficiency engineer of the Cleveland Automatic Machine Co., assistant superintendent of the Gisholt Machine Co., mechanical superintendent of the Diehl Mfg. Co., superintendent of the Van Dorn Electric Tool Co., and general superintendent of the Hero Mfg. Co. He was associated with Mr. Doud at both the Diehl Mfg. Co. and the Hero Mfg. Co. D. F. Bruce has been appointed superintendent in charge of manufacturing and production. Mr. Bruce has had extensive mechanical experience with such concerns as the Remington Arms Co., and the J. E. Lonergan Co., and was formerly superintendent of the McCambridge Co. The company is preparing to give field and consulting service, including time and production reports on questions regarding precision and thread grinding. New products and attachments are being developed, which will soon be announced.